UNITED STATES ARMY RESERVE IN OPERATION DESERT STORM

Engineer Support at Echelons Above Corps: The 416th Engineer Command

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FOREWORD

This is one in a series of monographs describing and assessing the role of the United States Army Reserve in winning the war in the Persian Gulf. Countless reports have been written and numerous books published about the coalition victory. None have appeared, however, that focus on the valuable contributions of Army Reserve soldiers and civilians to the favorable outcome of the conflict. This monograph and others in the series fill that void.

This report is about engineer operations above the corps level during Operation Desert Storm. Specifically, it is the story of the activation, deployment and employment of the Army Reserve 416th Engineer Command, the theater engineer command for the Coalition Forces engaged in the war. The report discusses several phases of engineer support to a number of U.S. corps and the unique functions performed by this United States Army Reserve General Officer Command. This is a success story of significant proportions demonstrating the dedication, professionalism and commitment of a talented group of Reservists working side by side with Active Component soldiers and performing their assigned wartime mission.

Other monographs will be issued to describe the roles of a variety of Army Reserve units and individual soldiers. They will include military police, infantrymen, civil affairs specialists, trainers, communicators, medical personnel, transporters and strategic intelligence units. These monographs, and the results of additional research on contributions of the Army Reserve to operations in the Persian Gulf, will be bound eventually in a single volume.

Your comments on this and future issuances are most welcome.

FOR THE CHIEF, ARMY RESERVE:

RONALD E. SMITH
Colonel, General Staff
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UNITED STATES ARMY RESERVE
in
OPERATION DESERT STORM

ENGINEER SUPPORT AT ECHELONS ABOVE CORPS:

The 416th Engineer Command

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The views, opinions, and findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless designated by other official documentation.

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ENGINEER SUPPORT AT ECHELONS ABOVE CORPS:

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The Senior Engineer

One of the features of Operation DESERT STORM at Headquarters, Third U.S. Army--ARCENT--was the weekly host nation support meeting at which the Commanding General, John J. Yeosock, met with his counterpart, Lieutenant General Khalid Bin Sultan, Saudi Arabian Armed Forces. The two commanders met with their respective staffs to discuss, plan, and arrange the way in which the US Army soldiers would operate and the support which the Saudi Arabian Government would provide. Often during these meetings, it was necessary to obtain a report or advice on a matter pertaining to real estate, construction, facilities, roads, or other engineering matters. At these times it was usual for both General Yeosock and General Khalid to turn to the senior Army engineer officer in the theater--Major General Terrence D. Mulcahy--and ask for an opinion, a report, or some urgent action. General Mulcahy would take on the missions assigned by the ARCENT commander and accomplish them. This was routine and in accordance with the normal methods for running a large military organization--except for one thing. General Mulcahy was an Army Reservist, a part-time soldier called to active duty for the war.[1]

General Mulcahy was the commander of the 416th Engineer Command, Chicago, Illinois. He commanded over 5,000 engineer troops and represented at the ARCENT level the approximately 20,000 engineer troops assigned to the two corps and their divisions. His command included an Army Reserve engineer brigade headquarters commanded by a Reserve brigadier general, three Active Component battalions, one National Guard battalion, and several separate companies and detachments of all components. His own organization and the engineer structure for ARCENT was completely integrated into a single force for the war. General Mulcahy and the Army Corps of Engineers applied the Total Army Concept well, perhaps better than any other branches or functional areas. They were Engineers first, and only incidentally Regulars, Reserves, or National Guard. Why this was the case and how it worked is an important aspect of Operation DESERT STORM.

Background of the Engineer Effort

Forty Years of Preparation

The Southwest Asia Theater (SWA) was either an engineer's dream or an engineer's nightmare--or both. It was hostile, barren, either too hot or too cold, lacking water, bereft of a robust infrastructure, and a hard place to work. It required a massive engineer effort to prepare the infrastructure (roads, pipelines, ports, housing areas, depots, and other facilities) required to support combat operations of a force totalling almost a million men on the Coalition side. In addition to the dangerous tasks of the combat engineers, there was plenty of construction to be done, real estate to be leased, facilities to be operated, and maps to be made and distributed. Fortunately, much of the work had been done before the US Armed Forces arrived in the theater--or even before Saddam Hussein invaded Kuwait in August 1990. In fact, the engineering and construction work to support this war started forty years earlier with the initial build up of Saudi Defenses.

In 1951, the U.S. Corps of Engineers began construction of a U.S. Air Force Base at Dhahran, which later was turned over to the Kingdom of Saudi Arabia. Other construction projects followed, and in 1972 the Saudi Government asked the Corps of Engineers to manage the construction of a military infrastructure. Under the supervision of the Corps, contractors were brought on board to design and construct ports, airfields, roads, and three massive military cities to house and provide support facilities for large armed forces. King Faisal Military City was located in the South to face Yemen; King Abdul Aziz Military City was located in the Northwest to face a threat from Syria and Jordan; and King Khalid Military City was located in the Northeast to face a threat from Iraq and Iran. In addition, naval and air force facilities were expanded and improved.[2]

Altogether, the Saudi Government spent at least $14 billion to prepare facilities against the possibility of an attack from outside. This was highly fortunate, for when the US and other Coalition forces arrived in Saudi Arabia, they found excellent port facilities, a reasonably good highway network, a telecommunications system, and a substantial number of buildings and other facilities to house the troops and administer the units. The pre-war construction not only saved time and money, but it allowed the U.S. to reduce its engineer force structure in the theater below what otherwise would have been required. Fifty years of preparation paid off in DESERT STORM--not only in terms of what was built, but also in terms of the trust that was built up between the Army and the Saudi Arabian Government.[3]

Engineer Missions

The Army Corps of Engineers provides seven basic kinds of services: construction management; real estate; combat support; facilities engineering; construction; water supply; and topographic support. To do this, the Corps of Engineers maintains two different kinds of capabilities.

Army engineer units ranging from detachments to companies, to battalions, and organized into groups, brigades, and commands, provide engineer support for the army-in-the field. These are part of the divisions, corps, higher headquarters, and major commands of the Army.

The U.S. Army Corps of Engineers (USACE) is a separate Army Major Command headed by the Chief of Engineers to perform other engineer missions for the entire Army, and, in the case of the civil works function, in support of the entire Nation.[4] USACE consists of about 40,000 personnel, 90% of whom are civilian employees. These people perform the engineer jobs of providing construction management services for both the Civil Works program and the Army Military Construction Program. The Corps of Engineers is organized into Engineer Divisions normally commanded by general officers--10 for the United States and three for overseas areas. Divisions are organized into Engineer District Offices headed by a colonel, and there are also special project offices in the command structure.

Construction management involves contracting for services and making certain the projects are constructed correctly. Corps of Engineers personnel do not themselves build buildings, dams, or roads or even supervise the workers who do; instead they supervise the contractors who undertake to perform the actual work. The construction management function involves working with architect-engineer firms to design the facilities and construction companies to assure that the designs are followed in the work.

Real estate operations are managed by the Corps of Engineers for the Army and the Air Force. The real estate function involves leasing or purchasing facilities, land, or easements to permit the Army or Air Force to use them for its own purposes. As might be expected, this is a mission which requires special expertise.

Combat support is designed to facilitate the movement of friendly forces (mobility), impede the movement of enemy forces (counter-mobility), and protect friendly forces (survivability). Assisting the friendly forces involves building and maintaining roads, bridges, and airfields, clearing mine fields, and breaching obstacles. Impeding enemy movement involves destroying roads, bridges, and airfields, laying mine fields, and creating obstacles. Protecting friendly forces involves assisting troops to construct weapons emplacements and bunkers to provide cover from enemy fire. Combat engineers use tanks and armored engineer vehicles with bulldozer blades mounted on them, as well as more conventional construction

equipment, such as bulldozers, front-loaders, cranes, dump trucks, and air compressors with pneumatic tools. Combat engineer units perform both horizontal construction (roads and airfields) and vertical construction (buildings and camps) as required to support the other units. Combat support is provided by divisional and corps combat engineer battalions in all components.

Facilities engineering involves maintaining and operating existing bases and buildings used to house the troops and provide office and storage space for units and headquarters. This is a large order at permanent bases in peacetime, and it is an even more demanding task to accomplish in a wartime theater of operations.

Construction is accomplished both by engineer troop units and by contractors. The Army relies extensively on contractors to accomplish major construction projects even in a theater of operations. Army combat heavy battalions have a limited capability to perform essential theater of operations work in close proximity to the fighting corps. Much rear area construction is performed by contractors under theater engineer supervision.

The responsibility for water supply in the U.S. Army is divided between the Quartermaster Corps and the Corps of Engineers. Quartermaster units operate water supply points, purify the water, and distribute it to the units using tank trucks, tank trailers, and pipelines. Engineer units locate water sources and drill wells to obtain it from subsurface sources. Water was a very important resource in the war with Iraq.

Topographic support in a theater of operations is provided by specialized engineer units which prepare and print maps and special topographic products, including terrain analyses, to supplement the work of the Defense Mapping Agency.

Accomplishing these seven major missions and all of the myriad included tasks requires a large and diverse force structure.

Army Engineer Force Structure in a Theater of Operations

The Army engineer force structure in being at the outbreak of the war with Iraq was quite different from that which existed in the 1970s or earlier. After the conclusion of the war in Vietnam, and the reorientation of the U.S. Army toward a global war with the Soviet Union, with the major land battle planned for Central Europe, the Army engineers gave much thought to how best to provide engineer support in a theater of operations. The resulting force structure was driven by two opposing realities. The first, that engineer support would be more difficult, more demanding, and more important than previously thought because of the requirement in Europe to keep the infrastructure intact, while under attack, and the requirement outside Europe to build an infrastructure before military operations commence. The second reality was the

pressure to reduce the strength and proportion of engineer troops in the Army's force structure. The resolution of these conflicting realities led to a different emphasis on how the engineers would perform their missions. Three basic changes were made:

1. Military engineer units would focus on combat support to the divisions and corps. The capability to perform heavy construction of airfields, roads, and large structures or complexes would be eliminated from the active force structure. The Army eliminated engineer construction battalions and created combat heavy battalions with limited ability for earthmoving and light construction.

2. More reliance would be placed on contractors and host nation support to perform heavy construction in a theater of operations.

3. Most of the engineer units to perform the engineer mission at Echelons Above Corps (EAC) would be placed in the Reserve Components. The Active Army would provide an ability to support the Active divisions and a corps, plus some capability to support the EAC. The Reserve Components would provide the ability to support the Guard divisions, additional corps, and most of the EAC capability, particularly the specialized detachments for which there was little peacetime requirement.

The engineer force structure on the eve of the war with Iraq provided robust support to the combat corps. Each heavy combat division had an organic engineer battalion with five operating companies: one for direct support of each of the three brigades; one for general support of the division as a whole; and a bridge company to provide that capability to the division commander. The light divisions had organic engineer battalions with three or four line companies. At the corps level, an engineer brigade headquarters commanded several engineer groups and numerous engineer corps combat battalions. A corps engineer group with two or three combat engineer battalions, provided direct support to each division in the corps. In addition, several types of separate companies provided specialized capability or support. Combat Support Equipment (CSE) and Light Equipment (LE) companies augment the capability of the corps combat or divisional battalions to perform horizontal construction--roads and airfields. Bridge companies provide the equipment and knowledge to construct fixed or float bridges. Engineer support for a corps had increased and was going to increase even more, for the Army already was contemplating providing even more engineer support for the combat divisions.

Additional engineer troop units were provided at the theater army or EAC level to support both the corps and the rear area units. Combat heavy battalions provide the troop construction capability for tasks too dangerous for contractors, while specialized separate companies and detachments provide additional capability for pipeline construction, well drilling, utilities, and construction equipment augmentation. Construction support companies, for example, provide a capability to operate a quarry, crush rock into aggregate, and produce asphalt pavement material. The work of several combat heavy battalions and separate companies

was supervised by group headquarters, and several groups would be under the command of an engineer brigade headquarters. At the theater army level, there would be a theater engineer command headquarters to command all of the EAC engineer units and provide support and technical guidance to the corps and division engineer units. The engineer command would plan, design, and coordinate all of the varied construction projects by troop units, host nation units, or contractors necessary to construct and maintain the elaborate infrastructure required to support modern armies in combat.

Recognizing the need for high level engineering and design capability at the theater level, the Army in 1971 created two engineer command headquarters in the Army Reserve: the 412th Engineer Command, Vicksburg, Mississippi, and the 416th Engineer Command, Chicago, Illinois. The task of these two headquarters was to plan, and prepare in peacetime to command, in wartime the full scale of engineering activities for a theater of operations. This capability was placed in the Army Reserve because the Reserves could provide personnel with the high degree of professional engineering competence needed to do this work, and the assignment stability to assure they would be available over an extended period of time. These two headquarters were already available when an important new mission was assigned to them.

In 1980 the Army completed a Joint Contingency Construction Requirements (JCCR) Study that rationalized and justified the new Army engineer force structure. In addition the JCCR formalized a Civil Engineer Support Planning (CESP) process, which later was made part of the Joint Operational Planning System. The idea was to determine in advance the engineer requirements at echelons above corps, by OPLAN, for each potential contingency theater of operations. The doctrinal combat support missions of Army engineer units to the corps and the Air Force civil engineering support for initial bed down and airfield damage repair were not included in these estimates. The Army would plan for theater contract and troop construction to support the OPLANs for the European Command (4102), Pacific Command (5000 series), and Central Command (1000 series). It was soon discovered, however, that the Army Major Commands lacked the personnel to perform this civil engineer support planning, so the mission was given to the two Army Reserve engineer command headquarters in the force structure.[5] The 412th Engineer Command was designated to be the wartime ENCOM for the European Theater. The 416th Engineer Command was almost eliminated at this time, but the Rapid Deployment Joint Task Force for the Southwest Asia Theater was being formed, and in 1983 the 416th Engineer Command was designated to be the wartime construction planning headquarters for that theater.[6] Later, the 416th was also given the mission to support the US Forces in Korea. Thus, at the outbreak of the war with Iraq, the 416th Engineer Command had been working for eight years on construction planning to support a contingency operation in the Southwest Asia theater.[7]

The 416th Engineer Command is a headquarters authorized 263 personnel, including 90 officers. Two unique features about the 416th Engineer Command headquarters are the professional qualifications of its staff and the distances they travel to train. Over 50 of the

officers on hand at the start of the war with Iraq were professionals within the architectural and engineering community.[8] Many officers travelled immense distances to drill with the unit. The Commander, General Mulcahy, lives in Waunakee, Wisconsin;, the deputy commander, Brigadier General Max L. Schardein, lives in Bettendorf, Iowa; other officers live in New York, Florida, and Utah, but commute once a month to attend weekend training with the unit.[9] This indicates a great deal of dedication on the part of the officers and points up that for these people the job is more important than convenience or pay. That job is knowing how to plan, design, and manage large and complex construction projects. Design of facilities involves knowing the principles and practical points of engineering; what is needed to withstand the anticipated loads and usage of a structure and how it must be built? Construction planning involves knowing what needs to be built and where. At the outbreak of the war with Iraq, the 416th Engineer Command was intended to be, and was, the repository of this special kind of knowledge for the intended theater of operations.

Engineer Forces in DESERT STORM

Despite all of the advance construction, considerable engineer effort was needed to support Operation DESERT STORM. Each of the services participating in Operation DESERT STORM faced a different situation with respect to engineer work. The Navy basically stayed afloat and operated from established permanent bases in Bahrain, and had little demand for field engineering or new construction. The Air Force operated out of existing airfields, which it shared with Coalition air forces, but needed engineer support to take care of its own bed down requirements. The Marine Corps operated along the coast from existing Saudi bases, but needed extensive construction support, as well as combat support, for its own operations. The Army operated initially from existing air and sea ports but moved quickly out into the open areas where there was insufficient infrastructure to support the housing and operations of its units. The Army had the most demanding engineering requirements and deployed the largest force of engineers to meet them.

Both the Air Force and the Marine Corps had significant engineer capability in the theater. The Air Force deployed a PRIME BEEF team with almost every flying squadron, with the engineer teams arriving at the same time or shortly after the squadrons. A PRIME BEEF (Primary Engineer Emergency Force) team has from 24 to 200 personnel and specializes in rapid runway repair and force bed down. These teams were supplemented in the theater by RED HORSE civil engineering squadrons to perform larger missions beyond the capability of the PRIME BEEF teams. A RED HORSE squadron has 400 personnel and can accomplish major construction projects.[10] The Marine Corps had substantial engineer support. There was a divisional engineer battalion with each of their two divisions in the theater and an engineer battalion in the Force Service Support Group of each of the two Marine Expeditionary Forces (MEFs), as well as some engineer capability in each of the two Marine Air Wings. The Navy provided four Mobile Construction Battalions (CBs) which were placed under the operational

control of MARCENT for the operation.[11]

The buildup of Army engineer forces occurred in three major phases. Phase I was the initial buildup during August, September, and October 1990 to defend Saudi Arabia with XVIII Airborne Corps. Phase II was the buildup during November and December 1990 to support offensive action with two corps. Phase III was the development of a mature theater engineer force structure to support offensive operations during January and February.

Defensive Phase: August - October 1990.

The initial buildup of Army engineer forces was conditioned by the mission of DESERT SHIELD to defend Saudi Arabia and a desire to minimize the construction effort. Emphasis was on providing combat power forward to deter an Iraqi attack and then defend Saudi Arabia. The engineer emphasis was on combat support. Facilities would be austere and construction would be minimized. A conscious decision was made to rely heavily on contractors to provide essential construction services and not to deploy combat heavy battalions and other EAC engineer troop units to the theater.[12]

The outbreak of the war on 2 August 1990 found the Engineer Section at Third Army headquarters staffed with only eight officers. After Third Army became ARCENT and deployed to Saudi Arabia, five of these officers were located at Dhahran occupied with immediate problems to bed down the arriving troops. Only three engineer officers were at Riyadh to perform the demanding tasks of estimating engineer requirements and planning for the troop buildup. At the same time, CENTCOM needed help in establishing engineer requirements for the entire theater. Lieutenant Colonel Donald Tomasik, the Third Army Engineer at the outset, moved to Saudi Arabia in late August 1990 and served at ARCENT (Forward) at Dhahran with the Provisional Support Command until November 1990, when he moved to ARCENT headquarters. Colonel Philip W. Carroll, III, became the ARCENT Engineer in December 1990.

The first senior engineer headquarters located in the theater was the 20th Engineer Brigade of the XVIII Airborne Corps. When the first troop transport landed in Saudi Arabia on 4 August 1990 with the Assistant Division Commander of the 82nd Airborne Division, the assistant corps engineer and the corps topographic staff officer were on the plane. Colonel Robert B. Flowers, the Corps Engineer and Commander of the 20th Engineer Brigade, arrived on 4 September 1990 with a tactical headquarters element. The rest of the 20th Engineer Brigade Headquarters arrived on 20 October 1990. While the primary mission of the 20th Engineer Brigade was to provide combat support for the XVIII Airborne Corps, it found itself involved also in theater army engineer matters, for which it was not staffed. Colonel Flowers and his staff planned helipads, life support areas, and other facilities for the arriving units, leased 276 pieces of civilian construction equipment, set up a construction materials supply

point, constructed ranges and rehearsal sites for troop training, and became involved in contracting for construction. Colonel Flowers found it difficult to be the Corps Engineer and the Theater Army Engineer at the same time.[13] The need for a headquarters to provide engineering and construction management for ARCENT was becoming apparent. There was barely enough engineer staff capability to deal with day-to-day problems, and there was a shortage of engineering design capability and insufficient capability to plan future operations.

At this time, the Theater Army logistical system was being created under the leadership of Major General William C. Pagonis. A Provisional Support Command headquarters (which later became the 22nd Support Command) was formed to manage all Theater Army logistics. The need for engineers to support the logistical system was also apparent. In the absence of a senior engineer headquarters at the EAC level, General Pagonis set out to create his own engineer capability by keeping Lieutenant Colonel Ken Cargill of the ARCENT Engineer Section at Dhahran to serve effectively as the SUPCOM Staff Engineer, ARCENT (Forward).

At the instigation of Lieutenant General Henry J. Hatch, Chief of Engineers, USACE had also moved out rapidly after the Iraq invasion of Kuwait to provide engineer support in the theater. Operating funds were used to deploy personnel of the Middle/East Africa Projects Office (MEAPO) from Dulles International Airport, near Washington DC. MEAPO, commanded by Colonel William A. Miller, and located at Winchester, Virginia, was the DOD design and construction agent for the Middle East and Africa with field offices in Egypt, Oman, Bahrain, Kuwait, Morocco, and Saudi Arabia. Ben Woods, a civilian employee of MEAPO, was the first to deploy, arriving in Saudi Arabia on 14 August 1990. Two days later, Lieutenant Colonel Charles S. (Stoney) Cox, flew to Riyadh with two contracting officers, a real estate specialist, and a construction engineer. On 17 August 1990, the Dhahran Area Office (DAO) of MEAPO was established in support of General Pagonis' Provisional Support Command.[14] The DAO grew to a strength of 110 with about 170 personnel moving in and out of the office.[15]

Major William Frost of the 416th Engineer Command deployed to the theater in September 1990 to act as the 416th Liaison Officer to ARCENT Headquarters, and he was frustrated by the gap between what had to be done and the engineering capability available to do it.[16] Others felt the same way, and the engineer staff officers at ARCENT and CENTCOM began to agitate for the deployment of the 416th Engineer Command.

The 416th Engineer Command was waiting the call. The headquarters had been involved in planning for the forthcoming operation in support of FORSCOM and Third US Army since the outbreak of the war on 2 August 1990. On 11 August 1990, the 416th Engineer Command sent Lieutenant Colonel Ben M. Colcol to CENTCOM to act as the ARCENT representative to the CENTCOM Regional Contingency Construction Management (RCCM) Team which was estimating engineer requirements for the DESERT SHIELD deployment. On 20 August 1990, a 416th Civil Engineering Support Plan (CESP) Team of four majors (Selton J. Sampson;

Norman J. Holmes; John L. Coath; and Kenneth C. Henning) reported for active duty with CENTCOM Headquarters to prepare a cost analysis of new facility construction in the theater. This mission required the conversion of the existing software program, which had been designed to provide estimates of engineering effort, to one which provided direct costs. The CESP team revised the software and completed the study, which was used by CENTCOM to justify to Congress and Coalition Governments the anticipated operational costs of construction.[17] The initial CESP estimate of $1.6 billion was quite accurate, since the final total was about $1.4 billion. This initial planning effort also provided CENTCOM a basis for requesting engineer units and contracting with private firms.

Despite the urging of engineer staffs, force planners were reluctant to call up the entire Engineer Command headquarters. Constraints on airlift and a desire to avoid too many high level headquarters were part of the basis for this reluctance. Another factor may have been the perception that Headquarters, Department of the Army, was discouraging the call up of Reserve general officers.[18] The compromise solution to provide some engineering and construction planning capability in the theater immediately was to call up and deploy an advance element of the 416th to serve as a surrogate for an Engineer Command headquarters, and a fall back in case the entire command did not deploy.[19]

On 15 October 1990, a 25 man detachment of the 416th Engineer Command was activated to provide a Theater Army engineer planning element in the theater. The 416th Engineer Command Forward arrived in Saudi Arabia on 30 October 1990 under the command of Colonel Alan J. Berg, Assistant Chief of Staff, Facilities Engineering. This group of 19 officers and 6 enlisted personnel was staffed deliberately to provide a superior technical engineering design capability, including computer assisted design (CADD) software and reproduction equipment.

Upon arrival in Saudi Arabia, the 416th Advance Party was located in Dhahran and subordinated to the Provisional Support Command. On 1 November 1990, General Pagonis issued a mission directive to the 416th Advance Party which placed them under the command of the Deputy Commanding General for Logistics (Pagonis) and assigned the following missions: theater real property maintenance activities; facility master planning support; management of theater real estate and housing programs; troop construction project design and coordination; environmental program management and hazardous waste disposal; maneuver damage control; and management and control of theater Class IV materials. The 416th also was directed to assume command of all EAC engineer units already in the theater, including the 308th Engineer Detachment (Real Estate) and the 535th Engineer Detachment (Prime Power).[20]

One of the first things that Colonel Berg did was to augment the Engineer Sections of CENTCOM and ARCENT with engineer officers to provide a construction planning and technical design capability. Three officers were assigned to augment the CENTCOM Engineer Section and two to the ARCENT Engineer Section. The remaining 20 members of the 416th

Advance Party remained in Dhahran. Colonel Berg located his headquarters near the Dhahran Area Office of MEAPO to facilitate close coordination. The Dhahran Area Office of MEAPO had been doing all of the engineering design work for ARCENT prior to the arrival of the 416th Advance Party, sending some designs back to MEAPO Headquarters in Winchester, Virginia, to be done, and letting contracts for some with local engineering firms. The 416th Advance Party augmented the available design capability and focused on theater level construction planning.

Colonel Berg became the de facto staff engineer for General Pagonis, Commander of the 22nd Support Command, who more or less in jest called the 416th Advance Party "his engineer command."[21] General Pagonis was aware of the need for engineer support, but he was also in dire need of logisticians to perform many tasks, so he tended to want the engineers to do some tasks normally the responsibility of area support groups, such as operating troop housing areas. Colonel Berg worked closely with Lieutenant Colonel Cargill, the SUPCOM Engineer and Lieutenant Colonel Stoney Cox, in charge of MEAPO's Dhahran Area Office, to meet all of the various demands for engineer support, even while a major change was in the wind for the whole thrust of the operation.

Offensive Planning Phase: November - December 1990.

In early November 1990 when the ARCENT mission was changed to be prepared to attack the Iraqis and drive them out of Kuwait, it was decided to provide additional engineer assets to support XVIII Airborne Corps and VII Corps and some assets for EAC as well. During this period, VII Corps deployed to the theater from Germany, bringing with it most of its engineer support, including the 7th Engineer Brigade. As the force buildup grew, the necessity to provide facilities to house and support the troops became apparent, and some additional EAC engineer units were deployed. The force planners at ARCENT started with the CAPSTONE trace for OPLAN 1002, essentially a doctrinal engineer force for a two corps mature theater, and eliminated the units for missions such as airfield construction which would not be necessary in Saudi Arabia. The planned engineer force included seven divisional engineer battalions, 10 corps combat battalions, 10 combat heavy battalions, six group headquarters, and numerous separate companies and detachments.[22]

Actions to build up the EAC support for the forthcoming offensive phase were proceeding rapidly. Colonel Berg moved with three officers to King Khalid Military City (KKMC) in early December to support the area support group responsible for preparing KKMC for occupancy by US Army forces. General Pagonis wanted construction work done at the log base near KKMC, but the 416th Advance Party had no troops other than the three small detachments it picked up upon arrival. Colonel Berg contacted Colonel Flowers, Commander of the 20th Engineer Brigade, who made the 62nd Engineer Battalion available to the 416th on an informal basis to accomplish essential construction in the vicinity of KKMC.[23]

In the meantime, it remained uncertain as to whether the entire 416th ENCOM headquarters would be deployed or not. Three times the unit was placed on alert status and removed, reflecting the resistance of CENTCOM and ARCENT to yet another headquarters. Finally, however, the theater realized that it could not continue to perform engineer construction management and design on an ad hoc basis.[24] On 29 November the entire headquarters was called to active duty and started processing for deployment at nearby Fort Sheridan, Illinois.

Unlike some other instances where calling a Reserve general officer to active duty was opposed by the Department of the Army, the call up for Generals Mulcahy and Schardein with their unit occurred without great difficulty. The position taken by the Chief of Engineers was that if the unit goes, it goes with its commander, and this was approved, despite some reluctance, by the Department of the Army.[25]

Figure 1.

Initial Allocation of Major Engineer Units: Desert Shield

	EAC	VII Corps	XVIII Corps
Command Hqs	1	-	-
Brigade Hqs	1	1	1
Group Hqs	2	2	2
Combat Heavy Bns	5	2	2
Composite Bns	1	-	-
Topographic Bns	1	-	-
Corps Combat Bns	-	7	5
Divisional Bns	-	4	3

The 416th Engineer Command main body arrived at Riyadh on 11 December 1990, and took charge of the EAC engineer units shown in figure 1. To manage these units, the 416th Engineer Command worked from three locations in the theater.[26]

ENCOM Main Headquarters was in Riyadh, in close proximity to ARCENT Main Headquarters, where most of the engineer real estate, construction contracting, and operational

planning decisions were being made. The 416th Chief of Staff, Colonel Gaines B. Hall, was in charge of the Main Headquarters and its 100 personnel. General Mulcahy operated out of ENCOM Main but usually was visiting the engineer troop units, coordinating with the ARCENT staff, or travelling with the ARCENT Commander, General Yeosock.

ENCOM East was in Dhahran, near the ports and major troop housing facilities and the 22nd Support Command Headquarters. Colonel Kelley C. Smith, the ACofS Comptroller, was in charge of the 25 personnel of this element, whose primary responsibilities were pipeline construction, real estate operations, environmental matters, and liaison with the nearby MEAPO Area Office.

ENCOM North, with about 40 personnel, was located at King Khalid Military City under General Schardein, the Deputy Commanding General, to provide an engineer element to coordinate closely with ARCENT Forward Headquarters and the two corps engineer brigades, and support the 411th Engineer Brigade. (More on this unit later.)

The construction planning and engineering design capabilities of the 416th were divided between ENCOM Main and ENCOM North. The peacetime organization of the headquarters had both an engineering section and a facilities engineering section. The Assistant Chief of Staff, Engineering, was Colonel Lee J. Pryor, and the Assistant Chief of Staff, Facilities Engineering was Colonel Alan J. Berg. Just before the deployment, General Mulcahy combined these into a single Engineering Section headed by Colonel Berg with Colonel Pryor as deputy. Colonel Berg was located at ENCOM North with a significant engineering and design capability to provide water resource planning, soils analysis, materials testing, drafting, and graphics support for the 411th and the corps brigades. The Engineering Section at ENCOM North also prepared designs for airfields, heliports, roads, structures, and power systems. Colonel Pryor was located at ENCOM Main where the primary emphasis was on theater army construction planning and management and processing statements of need for construction projects.[27]

During the period between the call up of the 416th Engineer Command on 29 November and its arrival in theater, there was considerable discussion at CENTCOM and ARCENT about the necessity for calling up an engineer brigade headquarters in addition to the command headquarters. Based on the situation which met the 416th as it arrived in the theater, the decision was made to deploy an engineer brigade headquarters. The 411th Engineer Brigade, USAR, Brooklyn, NY, under the command of Brigadier General Richard G. Storat, was alerted for this mission. The plan was for the 411th Engineer Brigade Headquarters to command two engineer group headquarters, five combat heavy battalions, and seven separate engineer companies. The 411th Engineer Brigade Headquarters would manage the construction operations of the EAC units, allowing the 416th to concentrate on theater-level planning, design, engineering, and contracting.

Thus, as the prospect of offensive action heightened, the Army had deployed--or was in the process of deploying--to Saudi Arabia an engineer force structure capable, with substantial contractor assistance, of supporting both the combat corps and the Theater Army infrastructure.

Combat Phase: January - March 1991.

As planning for the combat phase--DESERT STORM--proceeded, there was a major shift in the alignment of engineer units. An assessment of theater engineer requirements at a meeting of senior engineer commanders in mid-December 1990 had resulted in their recommendation that additional units be provided the two corps for the forthcoming combat phase. ARCENT approved this recommendation, and three combat heavy battalions and two engineer group headquarters were reassigned from the 416th to the two corps brigades. This reduced both the amount of engineer troop effort available at the EAC level and the span of command of the 416th Engineer Command. On 29 December 1990, the allocation of engineer units was changed to the revised engineer force structure shown in Figure 2. Interestingly, however, by mutual consent of the parties, the three combat heavy battalions being shifted remained under OPCON of the 416th Engineer Command for two additional weeks (until 16 January 1991) to complete on-going projects in the vicinity of KKMC and the corps rear boundaries.[28]

Figure 2.

Revised Allocation of Major Engineer Units: 29 December 1990

	EAC	VII Corps	XVIII Corps
Command Hqs	1	-	-
Brigade Hqs	1	1	1
Group Hqs	-	3	3
Combat Heavy Bns	2	3	4
Composite Bns	1	-	-
Topographic Bns	1	-	-
Corps Combat Bns	-	7	5
Divisional Bns	-	4	3

The recommendation to shift three EAC engineer battalions into the corps was approved at ARCENT with full appreciation of the possible consequences. The major reason for this shift of engineer support forward was the unprecedented need for engineer support in the corps areas for the ground war. Roads, log bases, airfields, and heliports had to be constructed and maintained, and a great deal of effort had to be made in preparing to breach Iraqi obstacles in the assault. New equipment placed large demands on the engineers. For example, preparing small (250 feet) runways for unmanned reconnaissance aircraft took an engineer platoon several hours to construct, and since the runway locations changed daily, the practical effect was to place an engineer platoon with each unmanned aircraft unit on a full time basis. Another factor was the existence of a substantial support infrastructure in the rear areas and the availability of contractors to perform construction there.[29] Shifting additional engineer units forward may have caused some concern at the EAC level, but there were no complaints by the two corps receiving the additional engineer capability.

This major shift of engineer troop units, however, did cause ARCENT to reconsider the decision to deploy the 411th Engineer Brigade. The new allocation left the 416th Engineer Command in the position of supervising no group headquarters and only two combat heavy battalions, so the original rationale for a brigade headquarters was gone. Nevertheless, General Mulcahy pressed strongly for the brigade headquarters because he believed he needed the capability of the brigade to manage troop construction operations in the forward areas. After much deliberation of the pros and cons of having a brigade headquarters, the ARCENT staff recommended that the 411th Engineer Brigade be deployed as planned to provide a forward command and control headquarters for EAC construction management and keep the 416th staff "out of the weeds."[30] The 411th Engineer Brigade Headquarters arrived in the theater on Christmas Day and was operational on 27 December 1990.[31]

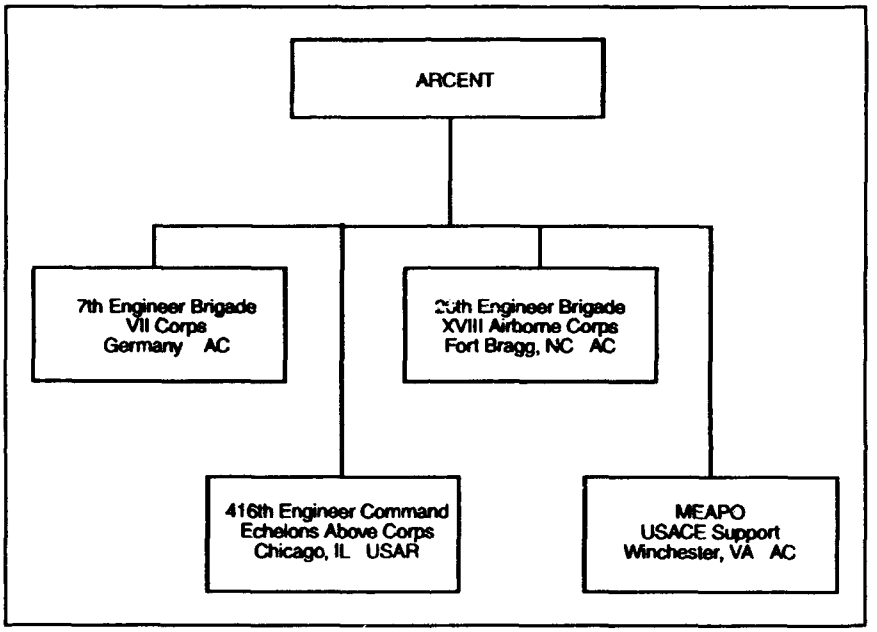
At the time of the realignment, a third combat heavy battalion, the 365th, was requested to augment the 411th Brigade, but the war was over by the time it was ready, and the main body was never sent to the theater, although an advance party of 10 personnel and its equipment did arrive. The advance party was re-embarked, and 220 pieces of engineer equipment were reloaded and sent home without contributing to the construction effort still in progress.

The engineer force structure in the theater consisted of 97 units--57 Active Component; 20 National Guard, and 20 Army Reserve. About half of the engineers at EAC were Reservists, and the proportion of Reservists in the two corps brigades ranged from 13% for the 20th Engineer Brigade to 18% for the 7th Engineer Brigade. Of the six engineer group headquarters, two were Active Component, three were National Guard, and one was Army Reserve. The total engineer strength in the theater consisted of 19,453 Active Component troops, 2,275 Guardsmen, and 1,953 Reservists, for a total of 23,681 engineers in the theater. Another 1,441 Guardsmen in two engineer battalions were deployed to Europe to backfill for some VII Corps engineer units which had moved to SWA.[32] The engineer force structure for DESERT STORM comprised about 4.4% of the total Army personnel in the theater.

Figure 3 shows the major Army engineer organizations in the theater at the start of Operation DESERT STORM.

Figure 3.

Major Army Engineer Organizations Under ARCENT



The organization shown in Figure 3 and the allocation of units shown in Figure 2 remained unchanged during the air war and ground war phases of the operation from January to March 1991. The operations of the EAC engineer units--what they did during this period--are described in the following sections. After the quick victory over Iraq and the liberation of Kuwait, the focus shifted to the redeployment of U.S. forces back to the United States and Europe.

Redeployment Phase: March - April 1991.

In the redeployment phase additional units were shifted to the 416th to do the work necessary to support units leaving the theater. The organization of engineer units at the start of the redeployment is shown in Figure 4.

Figure 4.

Allocation of Major Engineer Units: Redeployment Phase

	EAC	VII Corps	XVIII Corps
Command Hqs	1	-	-
Brigade Hqs	1	1	1
Group Hqs	3	1	2
Combat Heavy Bns	4	1	4
Composite Bns	1	-	-
Topographic Bns	1	-	-
Corps Combat Bns	1	6	5
Divisional Bns	-	4	3

As the time approached for the 416th to redeploy to the US, the mission of providing engineer support for the Theater Army was transferred to the 22nd SUPCOM. On 1 April 1991, the 416th Engineer Command established a forward headquarters at the 22nd Support Command Headquarters in Dhahran to coordinate the transfer of engineer projects, and on 15 April 1991 all EAC engineer missions were passed to the 22nd Support Command. The 416th Engineer Command main body redeployed to the US on 26 April 1991.

The 109th Engineer Group, a National Guard unit from Rapid City, South Dakota, under the command of Colonel Robert M. Benson, became the senior engineer headquarters for the 22nd Support Command and the Theater Army upon departure of the 416th Engineer Command. The 109th Engineer Group had arrived in the theater on 15 January 1991, and was assigned to the 7th Engineer Brigade for the combat phase, during which it had commanded two engineer battalions, two or three engineer companies, and a chemical decontamination company. On 18 March the 109th Engineer Group was assigned to the 416th Engineer Command to support redeployment activities. While operating directly under the 22nd Support Command from 15 April 1991 to 10 June 1991, when it redeployed to the United States, the group commanded two combat heavy battalions, three separate companies, and several detachments.[33]

Engineer Combat Support

While the focus of this historical case study is on engineer operations at Echelons Above Corps, it is necessary to understand the overall engineer effort in DESERT STORM to put into perspective how combat support operations influenced EAC operations. Most of the engineer troop units in the theater were involved in providing combat support to the divisions and corps. Of the 29 engineer battalions in the theater, 26 were assigned to the two corps brigades. This heavy support for the corps was in accordance with the evolving doctrine which recognized the need for extensive engineer support forward for the mobility and countermobility missions. It also was based on the fact that much infrastructure construction had already been done and on the assumption that contractors could do most of the additional work required in the rear areas.

Engineer combat support in DESERT STORM was influenced by a review of the combat engineer function which had occurred in 1985 and 1986. This study, called the Engineer Force (E-Force), concluded that combat engineer support in the divisions ought to be increased by 200% over previous support.[34] Instead of a 800 person battalion per division with a company to support each maneuver brigade, there would be a 1,600 person brigade per division with a 400 person battalion to support each maneuver brigade. This increase in divisional engineer support was justified by the emphasis on battlefield mobility to support the AirLand Battle doctrine. Heavy armored and mechanized forces needed more engineers to cross rivers and breach obstacles to permit the tanks and infantry to keep moving, while at the same time placing obstacles to limit the ability of the enemy to move. The divisional engineer brigade would be commanded by a colonel--the "Regimental Engineer".[35] As it turned out, engineer support for the XVIII Airborne Corps was carried out in accordance with current doctrine, while engineer combat support for VII Corps was influenced considerably by E-Force.

XVIII Airborne Corps Engineer Operations

The engineer effort in XVIII Airborne Corps initially was weighted heavily toward support of the 24th Infantry Division (Mechanized) with two of the three engineer groups supporting the thrust of that division northward deep into Iraq. Another engineer group was placed in direct support of the French 6th Light Armored Division to assist that division in its mission of screening the entire Coalition force from attack from the West.

The 20th Engineer Brigade task organization to provide combat support to the XVIII Airborne Corps is shown in Figure 5 as of 24 February 1991--the first day of the ground campaign.[36] Guard and Reserve units are shown in boldface to point up their contribution. The divisional engineer battalions and the engineer company organic to the armored cavalry regiment are marked with asterisks. After two days of the ground attack, the 265th Engineer Group and the 937th Engineer Group both reverted to general support of the corps to focus on

destruction and evacuation of enemy equipment and destruction of enemy ammunition and fortifications. The 36th Engineer Group remained in direct support of the 24th Infantry Division (Mechanized) throughout the ground campaign.

Figure 5 shows three Reserve Component engineer companies that were called up for Operation DESERT STORM to round out Active Component engineer battalions of the 20th Engineer Brigade. These were Company D, 52nd Engineer Battalion (Combat) (Heavy), Company D, 299th Engineer Battalion (Corps Combat), and the 212th Engineer Company, which "rounded out" the 62nd Engineer Battalion (Combat) (Heavy). Colonel Flowers, commander of the 20th Engineer Brigade, relates that he visited the 212th Engineer Company just after it arrived and became somewhat concerned when he learned that the average age of the members of the unit was 45 years, but the troops displayed a positive attitude and insisted on moving out to their work site immediately.[37] This "round out" program was adopted by the Army to offset force structure reductions in Active Component organizations. The engineer "round out" companies had been preassigned to the Active Component battalions, and had trained with them--including pre-DESERT STORM training on the ground in Southwest Asia. When they were called up and deployed to Saudi Arabia with their AC battalions, the Reserve Component companies did well--not unlike the AC units. They had a learning curve to come up to full effectiveness after activation, but so did the AC battalions. Colonel Carroll attributes the success of this small-scale "round out" program to the linkage established during peacetime between the AC and RC units. The AC battalions were held accountable for the training and readiness of the preassigned RC companies, and the units worked together on construction projects in austere environments. This allowed maximum use to be made of the civilian engineering skills of the members of the RC companies.[38]

VII Corps Engineer Operations

The U.S. VII Corps made use of the E-Force concept in the Southwest Asia Theater. When the war started in August 1990, the E-Force concept had been tested partially in the two heavy corps in Europe, so the divisions of VII Corps liked the idea and wanted to use the E-Force in the Southwest Asia theater. The 7th Engineer Brigade brought with it from Germany three mechanized engineer battalions (including one from the 130th Engineer Brigade), one combat heavy engineer battalion from the 18th Engineer brigade), one bridge company, and Company A, 649th Engineer Battalion (Topographic).[39] Additional corps engineer battalions were assigned, and three engineer colonels were appointed "Regimental Engineers" for the three divisions of the VII Corps. The task organization of 7th Engineer Brigade units on the first day of the ground campaign was as shown in Figure 6.[40] Guard and Reserve units are shown in boldface, and organic divisional engineer battalions and the engineer company of the armored cavalry regiment are asterisked.

The engineer battalions of the 7th Engineer Brigade had a major role in breaching the Iraqi fortifications and building roads to facilitate the rapid advance of VII Corps northward into Iraq. Two days into the ground campaign, the 176th Engineer Group reverted to a general support role to work on post-attack missions as described for the XVIII Airborne Corps. The 926th Engineer Group remained in direct support of the 3rd Armored Division.

The forward weighting of the engineer effort in VII Corps and in XVIII Airborne Corps was both necessary and successful. It was necessary to find a way to breach the barriers and fortifications erected by the Iraqi forces and then facilitate the ambitious maneuver missions of the combat elements of the two corps. There were some expected problems and some unexpected but great new developments in the engineer support. The older engineer vehicles could not keep up with the combat units equipped with M1 tanks and
M2 Fighting Vehicles; communications equipment was inadequate; mine detection difficult; mine rollers too slow; movement of construction materials uncertain; and more work available than could be done. However, the new M9 Armored Combat Earthmover (ACE) was a winner; mine rakes and plows worked well in breaching enemy mine fields at respectable speeds. After careful planning, these items were used together to conduct deliberate breaching operationsthat opened the door for the combat units. Once the breach was accomplished in each corps sector, the engineer emphasis turned to supporting the movement and resupply of the combat units by building combat trails and then roads.[41] The success of the engineer combat support effort was necessary for the rapid conclusion of the war with few US and Coalition losses. In turn, the success of the corps engineer effort depended on the work being accomplished by the engineers of the 416th Engineer Command.

Figure 5.
XVIII Airborne Corps Engineer Support

20th Engineer Brigade
175th Engineer Company (Corps Topographic) (OPCON)

6th Light Armored Division (French)
6th Engineer Company (French)*
937th Engineer Group (Direct Support)
20th Engineer Battalion (Corps Combat)
27th Engineer Battalion (Combat) (Airborne)
37th Engineer Battalion (Combat) (Airborne)

24th Infantry Division
3rd Engineer Battalion (Combat) (Mechanized)*
36th Engineer Group (Direct Support)
5th Engineer Battalion (Corps Combat)
299th Engineer Battalion (Corps Combat)
Company D (USAR)
72nd Engineer Company (SIB)
264th Engineer Company (Medium Girder Bridge)
362nd Engineer Company (Combat Support Equipment)

265th Engineer Group (General Support) (ARNG)
46th Engineer Battalion (Combat Heavy)
52nd Engineer Battalion (Combat Heavy) (- Co A)
Company D (USAR)
62nd Engineer Battalion (Combat Heavy)
212th Engineer Company (Combat Heavy) (ARNG)
844th Engineer Battalion (Combat Heavy) (USAR)

82nd Airborne Division
307th Engineer Battalion (Combat) (Airborne)*
618th Engineer Company (Light Equipment)

101st Airborne Division
326th Engineer Battalion (Combat) (Air Assault)*
887th Engineer Company (Light Equipment)

3rd Armored Cavalry Regiment
43rd Engineer Company (Combat) (Mechanized)*
Co A/52nd Engineer Battalion (Combat Heavy)

Figure 6.

VII Corps Engineer Support

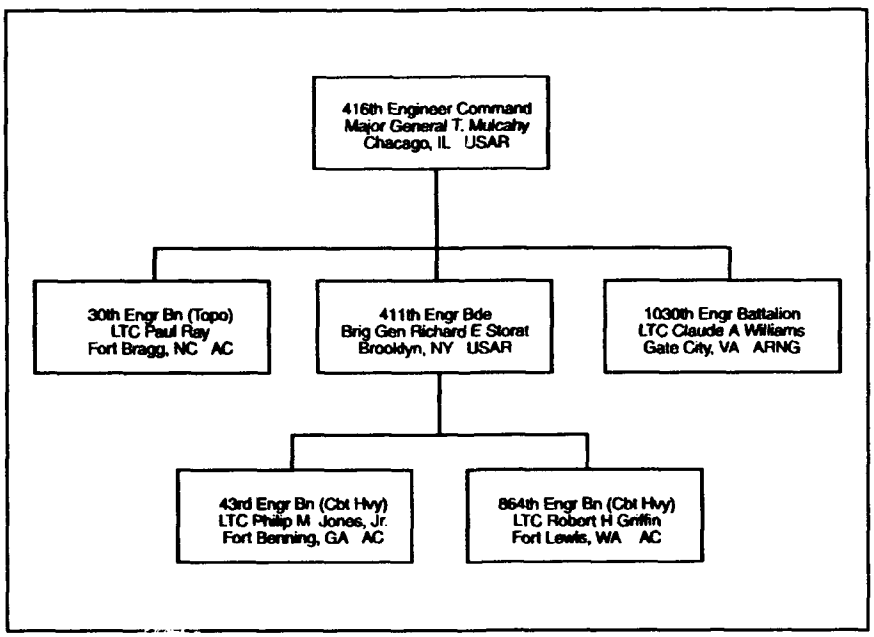
7th Engineer Brigade A Co/649th Engineer Battalion (Topographic) (OPCON) 38th Engineer Company (Medium Girder Bridge) 642nd Engineer Company (CSE) **109th Engineer Group (General Support) (ARNG)** **527th Engineer Battalion (Combat Heavy) (ARNG)** **131st Engineer Company (CSE) (ARNG)**
1st Infantry Division (Mechanized) "Regimental Engineer" 1st Engineer Battalion (Combat) (Mechanized)* Co D/17th Engineer Battalion (Combat) (Mechanized) 9th Engineer Battalion (Combat) (Mechanized) **176th Engineer Group (ARNG)** 249th Engineer Battalion (Combat Heavy) 588th Engineer Battalion (Corps Combat) 317th Engineer Battalion (Combat) (Mechanized)
1st Armored Division "Regimental Engineer" 16th Engineer Battalion (Combat) (Mechanized)* 54th Engineer Battalion (Combat) (Mechanized) 19th Engineer Battalion (Corps Combat)
1st Cavalry Division (-) 8th Engineer Battalion (Combat) (Mechanized)*
3rd Armored Division "Regimental Engineer" 23rd Engineer Battalion (Combat) (Mechanized)* 12th Engineer Battalion (Combat) (Mechanized) **926th Engineer Group (Direct Support) (USAR)** 92nd Engineer Battalion (Combat Heavy)
1st Armored Division (United Kingdom) 21st Engineer Battalion (Combat) (Mechanized) (UK) 23rd Engineer Battalion (Combat) (Mechanized) (UK) 52nd Engineer Battalion (Corps Combat) (UK)
2nd Armored Cavalry Regiment 84th Engineer Company (Combat) (Mechanized)* 82nd Engineer Battalion (Combat) (Mechanized) (OPCON)

Operations of the 416th Engineer Command

The major elements of the 416th Engineer Command during Operation DESERT STORM were as shown in Figure 7. The general allocation of missions was as follows. Responsibility for construction operations was assigned to the 411th Engineer Brigade. The 1030th Engineer Battalion was assigned the facilities engineering mission for all Army facilities in the theater. The 30th Engineer Battalion had the theater topographic support mission. The 416th Engineer Command retained under its direct control certain engineer missions that had theater-wide application.

Figure 7.

Organization of the 416th Engineer Command



While most of the engineer work was assigned to the three major subordinate headquarters, the 416th Engineer Command staff retained direct responsibility for certain engineer missions, including theater army engineer planning and design, real estate operations, prime power, contracting, and construction materials. In addition, the 416th Engineer Command performed certain special projects for ARCENT, one of which involved training Saudi engineer troops in obstacle breaching techniques.

Obstacle Breaching Training

At the outset the Coalition Forces realized that liberating Kuwait would necessitate breaching obstacles constructed by the Iraqis along Kuwait's southern and southwestern boundaries with the Kingdom of Saudi Arabia. These obstacles included tank ditches, fire trenches, fortified positions, barbed wire entanglements, and extensive mine fields. Breaching these obstacles to permit the unobstructed passage of tank, infantry, and artillery battalions, as well as support units, was the job of the combat engineers. The Saudi Armed Forces had a small existing engineer force incapable of accomplishing this mission over the broad front assigned to them, and decided to expand their combat engineer force structure enough to be able to accomplish the obstacle breaching mission. They requested U.S. Army assistance to help them achieve this expansion rapidly.

On 12 December 1990, the day after becoming operational at Riyadh, the 416th Engineer Command was given the mission of assisting the Saudi Forces to prepare an expanded obstacle breaching capability. The mission included the following elements: establish the tables of allowances for the personnel, equipment, and supplies to form two Saudi Special Breaching Battalions; design an obstacle training range that portrayed realistically the Iraqi defenses in southern Kuwait; develop training plans and train Saudi instructors; and provide construction management support to Saudi engineer construction units who would construct the ranges. The two new Saudi units were to be ready by 15 January 1991.[42]

The Deputy Commander, of the 416th Engineer Command, Brigadier General Max L. Schardein, formed a small task force, consisting of Lieutenant Colonel Merrill W. Watt and Captain Steven C. Woods, of the Engineering Section of the 416th, and Lieutenant Colonel James Bland, of the ARCENT Engineer Section. The task force moved to a forward area just east of the tri-border area and started to work immediately. It established a working relationship with the Saudi engineer commanders, prepared a milestone plan, gathered intelligence on the Iraqi defenses, researched the design of possible special breaching battalions, and visited the units of the 20th Engineer Brigade that had already been giving barrier breaching training to the US troops. Intelligence sources revealed that the Iraqi defenses consisted of a basic obstacle complex repeated in several echelons along the front. Each obstacle complex included a 10 meter berm, triple concertina wire, a tank ditch 10 meters deep, barbed wire entanglements, and a mine field, all deployed over a depth of 750-800 meters. Some of the tank ditches were filled with oil to be ignited in the event of an attack.[43]

The organization proposed by the Task Force for a breaching battalion, consisting of 32 officers and 524 enlisted personnel, was accepted by the Saudis. The units were formed and equipped expeditiously. Lists of equipment, including dozers, armored vehicle launched bridges (AVLB), combat engineer vehicles (CEV), mine detectors, smoke pots, shaped charges, and mine field marking kits, were presented to the Saudis in the morning, and the equipment was purchased that same afternoon.

Two ranges were built by Saudi engineer troops working from the 416th designs, supported by U.S. engineers of the 20th Engineer Brigade, and under the general supervision of General Schardein's task force. Company B of the 27th Engineer Battalion, commanded by Captain William Rapp, supported construction of a training range at Qaysumah in North Central Saudi Arabia. Company B of the 37th Engineer Battalion, commanded by Captain Randy Mallow, supported construction of a training range at Al Biyyal in Northeast Saudi Arabia. Each training range covered an area 8.6 km wide and 2.6 km deep and had nine platoon live fire lanes that extended the full depth of the range and included faithful replicas of Iraqi obstacles. Each lane also had an individual training site and a pit for demolitions practice.

The training started with emphasis on individual skills and progressed to platoon level exercises on the live fire lanes. Each Saudi engineer had to receive instruction at the individual training sites on such tasks as mine detection operations, using the bangalore torpedo, operating the mine clearing line charge, detonating a mine in place, mine field marking, operation of the CEV, mine plow, and AVLB, and platoon leader and sergeant leadership skills. After extensive preliminary instruction, the Saudi platoons moved down the live fire lanes practicing breaching techniques under control of their trainers. The experience of the 20th Engineer Brigade in performing similar training for U.S. troops in Saudi Arabia was very helpful in this operation.[44]

The training was successful. The Saudi engineer soldiers became aggressive and confident. The Saudi Breaching Battalion at Biyyal completed its training on 9 January 1991, and the battalion at Qaysumah, on 15 January 1991.[45] Subsequently, these two battalions did an outstanding job leading the attack of the Saudi Forces on the Iraqi defenses.

Construction Planning and Design

One of the major missions of the 416th Engineer Command was to provide support for the planning and design of the facilities to be constructed in the theater. The construction planning mission had started even before the 416th was activated, when a team from the 416th reported to CENTCOM Headquarters in Tampa, Florida, to work on the Civil Engineer Support Plan (CESP) for DESERT SHIELD. After the CESP had been prepared at Tampa, it was forwarded to CENTCOM Headquarters in Riyadh and used to validate the need for facilities and the associated costs. This was the first time that a CESP had been prepared for a real situation, and it proved to be of great value in doing the actual planning in the theater.[46]

When the 416th arrived in theater, the Engineering Section used the CESP results and planning factors to develop the actual requirements for the theater. The force deployment schedule provided a time-phased list of units and strength to be supported. Planning factors were applied to the projected troop and equipment population to determine the number and size of supporting facilities needed. An aviation battalion, for example, would generate a

requirement for specific amounts of parking apron, living quarters, water supply, and fire fighting support. These requirements were translated into labor hours, quantities of construction materials, shipping weights, and cost for each project. These estimates were used to estimate requirements for engineer troops, contractors, and construction materials. They were the basis for ordering and shipping the material, scheduling troop labor or awarding contracts, and obtaining prior approval for the projects.[47]

Construction planning and engineering had to be flexible. The numbers, types, and priorities of construction projects to be accomplished changed daily as the force built up and the mission changed from deter, to defend, and finally to offensive operations. Another factor for the overall construction plan was the desirability of using local construction materials and practices, which had not been considered sufficiently in the planning, conducted in the US, prior to the war. Once in the theater, the engineers adapted to local conditions. Another advantage was the availability of new types of temporary or semi-permanent structures which could be erected quickly.

A lot of construction was accomplished. Although the Army applied an "austere" standard for facilities in Saudi Arabia, and although there was some confusion on the exact meaning of the word, the intent clearly was to avoid building a massive base structure. The Army had gone overboard on bases in Vietnam and was not going to make that same mistake in the desert. Most of the housing requirements for EAC troops were met by facilities provided by the Kingdom of Saudi Arabia. Base camps were considered but never approved, and instead six austere Life Support Areas (LSAs) were built for troop occupancy, but only two of these were actually used, for most of the corps troops lived in the field in tents or their own vehicles. However, numerous airfields, heliports, logistical bases, roads, and temporary or semi-permanent structures for offices, warehouses, and maintenance shops had to be built. A tactical petroleum pipeline had to be designed and built. Wash racks had to be built so that vehicles being moved back to the U.S. could be cleaned to meet U.S. Department of Agriculture standards. Several hundred projects had to be planned, estimated, and designed.

Projects were designed and plans prepared for each construction project by the combined efforts of the 416th Engineer Command, MEAPO, and architect-engineer firms under contract to MEAPO. The design process often started with standard Army Functional Components System (AFCS) drawings and bills of material that were translated into detailed plans for each project. The 416th Engineer Command used computer assisted design and other modern construction planning software to prepare plans for over 100 facilities to be constructed by subordinate units of the command.

Real Estate Operations

One of the little appreciated but vitally important engineer functions in a theater of

operations is to buy or lease land and facilities needed to support the military operations. This was particularly important in Operation DESERT STORM because of the extraordinary reliance placed on support from the Host Nation--Saudi Arabia.

Real estate leasing operations started on 18 August 1990, the day after the arrival of Lieutenant Colonel Cox and his initial MEAPO team. The operation started with one real estate specialist but grew to a total of 36 personnel--20 civilians from USACE and 16 from the 308th Engineer Detachment (Real Estate). Since MEAPO did not have any organic real estate capability, the Savannah Engineer District of the South Atlantic Division was tasked in 1987 to provide this kind of support. Savannah District had developed a six person real estate team for contingency operations in the Middle East and had trained the team on local customs and leasing procedures. The entire team volunteered to go to Saudi Arabia to support Operation DESERT STORM. The first person to go was Rick Thomas, who accompanied Lieutenant Colonel Cox, followed five days later by Jim Ellis, Chief of the Real Estate Division, Savannah District. By mid-September there were 10 realty specialists and 2 appraisers, and by mid-October the real estate staff consisted of 18 personnel augmented by three local hire clerks. The civilian employees served 90 day tours in the theater, and several exercised their options to extend for another 90 days or return for a second tour. Altogether, about 40 different personnel were utilized in the real estate operations at one time or another.[48]

Leased facilities were absolutely necessary to provide beds and sanitary facilities for the incoming troops. The real estate people worked hard to negotiate and close the leases. The priority was to secure the needed facilities in the shortest possible time. The contracting officers were authorized initially to sign leases only up to $50,000 in annual rental, and this proved to be too small for the need. Upon request and as the urgency of the situation grew, the Department of the Army increased to $200,000, and then to $2,000,000, the leasing authority of the local contracting officer. Eleven leases exceeded the $2,000,000 amount and were referred to the Department of the Army for decision, with approval obtained in less than 24 hours in each case. Housing was leased to support about 49,000 personnel, and warehouses, offices, and hardstands were leased for the logistical and administrative support of the theater. In October 1990, 17 real estate specialists signed leases on 40 properties in just 17 days. By March 1991 leases had been negotiated for about $150 million in annual rental value.[49]

The 308th Real Estate Detachment, USAR, Bismark, North Dakota, under the command of Major Thomas M. Senger, was called to active duty on 11 October 1990, and deployed to Saudi Arabia on 30 October 1990. The unit had five officers, three NCOs, and eight enlisted personnel. Major Senger had taken command recently and had relatively little real estate experience prior to joining the unit; two captains and one enlisted person had joined the unit after it was activated. The long-term members of the detachment had trained on lease management and terminations, but were lacking in experience and training on lease negotiations and appraisals. The unit was located in Dhahran under the operational control of the Dhahran Area Office of MEAPO and were used to manage and service existing leases. They managed

contracts and agreements, resolved maintenance problems, made condition surveys, investigated and settled claims, prepared reports, and developed a computer listing of all leased properties in Saudi Arabia. This allowed the MEAPO real estate specialists to concentrate on negotiating and awarding the contracts. The 308th Engineer Detachment redeployed to the United States on 4 April 1991 with the satisfaction of having been a valuable asset to the real estate program in the theater.[50]

The 416th Engineer Command staff played a significant role in real estate operations in the theater by coordinating policy issues with ARCENT and CENTCOM headquarters. Major Frost of the 416th worked with the 22nd Support Command to develop priorities and guidance for the real estate operators.[51]

Construction Management and Project Approval

One of the major engineer tasks during Operation DESERT STORM was to manage the Regional Contingency Construction Management (RCCM) process by which approval and funding could be obtained for both contract and troop construction projects. Detailed justification for all military construction projects costing over $200,000 is required by Section 2805, Title 10, U.S. Code. During DESERT STORM, all requests for funding of new construction projects had to be processed using DD Form 1391, Military Construction Project Data. Minor projects estimated to cost less than $200,000 were approved by ARCENT. Major projects estimated to cost $200,000 or more were forwarded to CENTCOM, and those costing less than $1,000,000 were approved by CENTCOM, while those costing over a million dollars were forwarded to OSD and Congress for specific approval.[52] This had to be done even if, as was the case for DESERT STORM, the funds were available or the costs were paid by other nations.

The 416th Engineer Command became involved in the RCCM process in August 1990 when Major Stephan E. Ryeczek went on a 30 day tour to augment the Engineer Section at CENTCOM Rear Headquarters. Upon Major Ryeczek's departure, Major Christopher S. Prinslow served a 23 day tour at CENTCOM Rear. On 15 October 1990, Majors Ryeczek and Prinslow and Major Arthur J. Yarzumbeck deployed to Saudi Arabia as part of the 416th Advance Party, and on 7 November 1990, these three officers became the ARCENT liaison officers to the CENTCOM Joint RCCM Cell responsible for processing DD 1391s for all major construction projects in the theater. Captain Michael A. Alexander joined the Joint RCCM Cell on 5 December 1990.

The CENTCOM Engineer, Colonel John Braden, chaired meetings of the Joint RCCM Cell at which 1391s were reviewed and validated before they were submitted to the Deputy CINC for approval. The Joint RCCM Cell resolved cross-service needs, assured that sufficient funds were made available for materials, wrote delivery orders against approved 1391s, and

coordinated with construction units to assure that requirements were being met. The Joint RCCM Cell also made recommendations on the source of funding for projects--KSA (reluctant but available), Government of Japan (for a rapid reaction), Germany (services and equipment only), and the US Government (very little). CENTCOM policy was to give priority to readiness, then to survivability, and only then to bed-down. Construction was to be accomplished in such a way as to avoid giving the appearance of permanence. The ARCENT liaison officers facilitated approval of ARCENT projects by obtaining additional information quickly and explaining the rationale for requests. The RCCM process at CENTCOM facilitated orderly management of the massive construction program to support the operation.[53]

At ARCENT, however, the preparation and processing of 1391s overwhelmed the understaffed Engineer Section, and on 8 January 1991, the 416th received the mission of managing the approval process for new major military construction projects. The 416th became the central point for requesting all ARCENT construction projects. A request for a construction project originated with the unit wanting the facility--usually not an engineer unit. The 416th Engineer Command staff helped the requesting units describe what they wanted, determine the materials needed, and estimate the cost of the project. This assistance improved both the quality of the requests and the speed with which projects were approved. During the period 17 January 1991 and 10 March 1991 the 416th processed 42 requests for a total cost of $278.6 million. These projects included roads, airfields, heliports, hardstands, wash stands, displaced civilian camps, and hazardous waste cleanup projects. Most projects were for direct support of the corps. Each project was unique in nature and required a unique solution.[54] While the RCCM process was tedious, it was necessary to provide some order and make best use of the limited construction resources in the theater.

Prime Power Operations

One of the engineer units that worked directly for the 416th Engineer Command was the 535th Engineer Detachment (Prime Power), an active Army unit. The 535th was a specialized unit designed to provide electrical service to augment that provided by electrical generators organic to Army units in the field. During peacetime the detachment was stationed at Fort Monmouth, NJ, as part of the Prime Power Program operated by the U.S. Army Engineering and Housing Support Center (USAEHSC), Fort Belvoir, Virginia. Other prime power personnel were stationed in teams at other Army bases in CONUS, Hawaii, and Germany to provide electrical specialists for facilities engineers. The 535th was alerted on 11 August 1990, and Team One with 19 personnel arrived in Saudi Arabia on 7 September 1990, under the Detachment Commander, Major Dale A. Knieriemen. Due to restrictions on air lift, the team deployed with only three vehicles and hand tools and was not capable of accomplishing its prime power mission until its generators and larger equipment arrived. After its arrival, Team One was utilized in a facilities engineering role at Dhahran Air Base under a variety of higher headquarters. Team Two with 16 personnel arrived in theater on 22 November 1990, and its

equipment arrived by ship on 25 November 1990.

Perhaps because the prime power mission is poorly understood outside of, or even within engineer channels, the unit was not well utilized until the 416th Engineer Command arrived and assumed control of the detachment on 22 November 1990. Initially the 535th was attached to the 1030th Engineer Battalion, but in January 1991 it was placed directly under the Engineering Section of the 416th Engineer Command. Under the direction of the 416th, the 535th Prime Power Detachment was used in its intended role of providing power and electrical support to units in the field. One major mission was to provide power to two of the six planned Life Support Areas (LSA), but this mission was canceled later when it became apparent that the LSAs would not be needed in the campaign. The electrical technicians of the prime power detachment performed power surveys, design and redesign of electrical systems, prepared construction plans and bills of materials, and inspected electrical work performed by contractors. They accomplished 195 prime power missions including installation of primary and auxiliary power; operation and maintenance of existing power sources, design and construction of secondary distribution systems, commercial power hook-ups, load surveys, and interior and exterior wiring. In early March 1991, 11 members of the 535th served with the 416th Engineer Command's damage assessment team in Kuwait, and two members of the detachment set up the power for the cease-fire talks in Southern Iraq on 3 March 1991.[55]

Task Force Bravo of the Prime Power Program was formed in January 1991 to augment and then replace the 535th Engineer Detachment. Task Force Bravo, commanded by Major Kenneth E. Cockerham, consisted of a small headquarters, and two 8 person prime power teams: Team Three primarily from Germany and Team Four formed from USAEHSC personnel in the U.S.. After extensive training at Fort Bliss, Texas, Task Force Bravo deployed to the theater, with the U.S. based elements arriving on 1 March and the European based elements on 5 March 1991. Initially, Task Force Bravo worked alongside the members of the original 535th Detachment, and when the 535th Engineer Detachment redeployed to the US on 1 and 2 April 1991, Task Force Bravo assumed full responsibility for prime power operations in the theater. In June, as U.S. Army forces withdrew from the theater, Task Force Bravo prepared a plan to replace Army installed prime power plants with commercially leased and contractor operated generator equipment. By mid-July all of the Army installed prime power plants, except one, had been replaced with no loss of service.[56]

Task Force Bravo remained in the theater until it moved back to the U.S. and Germany on 19 August 1991. It was replaced in turn by Detachment Two of the Prime Power Program, which had arrived at Dhahran on 2 August 1991 under the command of Chief Warrant Officer Carlton Bruce to take over the mission and some of the equipment of Task Force Bravo. Detachment Two remained in the theater until 3 December 1991.[57]

Despite some difficulties initially because of lack of informed supervision, modern electrical equipment, and adequate materials handling equipment, the prime power detachments

and teams proved their value during the operation. Although the prime power mission to support the army in the field was not recognized in doctrine and there were no TOE units, the engineers managed to put together impromptu organizations to get the job done. Steps have been taken to improve the prime power program. During the war and afterward, the prime power capability has been formed into a provisional prime power battalion, headquartered at Fort Belvoir, Virginia. Essentially, Task Force Bravo and Detachment Two became Company A of the new battalion, and the 535th Engineer Detachment became Company B.[58]

Construction Materials

A task undertaken by the 416th Engineer Command out of necessity was control and distribution of Class IV engineer construction materials. There was a severe shortage of Class IV construction materials, which include cement, asphalt, sand and gravel for making concrete, prefabricated shelters, lumber, hardware, and fortification and barrier materials. The normal logistical system did order some Class IV items, such as concertina wire, lumber for bunkers, and tent floors for issue to troop units, but did not provide materials to support the construction work. The engineers were not always involved in estimating the demand for construction materials, and there were constant shortages which usually delayed the completion of construction projects.[59]

Part of the problem was the way in which the engineer forces deployed incrementally into Saudi Arabia. The 20th Engineer Brigade was the only engineer brigade in the theater for over 3 months and established its own Class IV Yard near Dhahran to store and control the Class IV materials it needed to do its work. Subsequently, when the 416th ENCOM set up the Theater Class IV yard at KKMC, it was difficult to persuade the 20th Engineer Brigade to release the materials it already had on hand for use by other units in the theater.

Prior to the arrival of the 416th Engineer Command there was no headquarters capable of estimating, identifying, obtaining, and distributing construction materials for all of the various engineer missions. The corps engineer brigades wanted barrier materials and expeditionary shelter systems. The EAC engineers wanted other kinds of materials. There w s little preplanning for construction materials, and requisitioning was on an as required basis after projects were approved.

It took great effort to break through the understandable resistance of other engineer headquarters, but the 416th Engineer Command was able to obtain control of the theater Class IV supply system. It established a Theater Class IV Yard at King Khalid Military City, which it staffed with 5 personnel from the Logistics Section of the Headquarters. Space for the Class IV yard and materials handling equipment to load the supplies was borrowed from the supply and service company in charge of the general depot.[60]

Obtaining Class IV materials was not easy because the engineer headquarters had neither contracting officers nor operating funds to procure the materials locally. Working through the other contracting officers was difficult because the normal logistical system tended to give engineer construction materials a low priority. The 416th Engineer Command and the 411th Engineer Brigade appointed officers to manage contracts for local purchase and work with ARCENT and the contractors at their respective locations in Riyadh and Dhahran. This was highly effective. The 416th managed a Blanket Purchase Agreement (BPA) totaling $64 million for lumber, asphalt, cement, gravel, and plumbing and electrical materials. The 416th also took delivery of more than $10 million worth of engineer equipment (163 major end items) through a CENTCOM contract funded by the Government of Japan.[61] The 411th Brigade contracted for about $2 million in rental equipment and $6 million in Class IV materials.[62]

The Class IV yard established by the 416th Engineer Command at KKMC was successful after a slow start. The 43rd and 864th Task Forces each established their own small Class IV yards at KKMC and Log Base Bastogne, respectively, and found that this was highly effective in keeping their projects on schedule. They used the larger Class IV yards as a general depot. Ironically, there were shortages during the buildup to the war but because of the short duration of the war, there were large amounts of Class IV in excess to needs after the cease fire.

Contract Construction Operations

Much of the construction work in the theater was performed by civilian contractors, and this generally worked well, although there are differences of opinion between the engineer unit commanders and MEAPO on contractor performance and utility of civilian contractors to perform construction work.

Engineer commanders generally have an unfavorable opinion of the performance of contractors in this operation. The commanders report problems and lack of responsiveness and say that when the shooting started, contract workers proved to be unreliable. There are reports that when hostilities commenced, many contractor personnel in the corps rear areas and the forward part of the communications zone simply stopped working and left the area of potential danger for periods from three days to as long as three weeks.[63] Some of their projects had to be completed by engineer troops.[64] In some cases, U.S. troops were teamed with contractor drivers with orders to take over the vehicle and drive on if contractor personnel refused to go. U.S. troops also operated and put to use contractor equipment abandoned on project sites.[65] There were also restrictions placed by U.S. combat commanders on allowing contractor personnel to work in their areas.[66]

Overall, the experience of the engineer commanders with contractors caused many of them to be less positive about relying on contractors than they were before the war. Contractors were considered to be good either for repetitive low-tech construction, such as building latrines

and wash basins, or for sophisticated one-time projects relying heavily on local materials and practices.[67] The engineer commanders conclude that contract construction proved to be useful to supplement troop construction in the theater of operations but would have been more useful if the commanders responsible for getting the work done had more control over the contractors to assure that there would be an integrated effort that would not be stopped completely in the event that contractors leave a combat area.

The MEAPO experience with contractors was more positive than the reaction of the engineers in troop units. MEAPO believes that contractor performance in DESERT STORM validates the policy of relying on contractors to meet some of the construction requirements during a contingency operation. MEAPO alone awarded $300 million in construction contracts for US forces and reports satisfactory performance from their contractors. Contract construction occurred throughout the theater--in Egypt, United Arab Emirates, and Bahrain, as well as in Saudi Arabia. Contractors filled the gap until substantial numbers of engineer units arrived in the theater. From August to October 1990, during the defensive phase of the operation, contractors were the only source of construction capability available at Echelons Above Corps because divisional engineer battalions focused entirely on combat support. The 20th Engineer Brigade units arrived in October 1990 and worked hard but were too few in number to meet the demand. As engineer troop strength increased, the demand for contractors shifted from support of the corps to the echelons above corps, and contractors contributed heavily to this effort.[68]

MEAPO also points out that it is unrealistic to expect civilians to behave in the same manner as soldiers in a combat area. For one thing, no preparations were made to provide contractor personnel even a basic capability to deal with the threat of chemical attack and SCUDs. Nevertheless, some contractors did continue to work despite the danger, and in all cases, contractor personnel returned to their jobs after they were provided the same chemical protective masks issued to the troops. Contractors constructing the KKMC Airport extension continued to work while under active SCUD attack. Overall, many contractor personnel displayed a high degree of patriotism and took personal as well as monetary risks to support the war effort.[69]

This is an important issue because a policy of reliance on contractor support was used to rationalize reductions in the engineer unit force structure. The experience of DESERT STORM does not provide a definitive answer. On the one hand, some incidents suggest that it may be unrealistic to expect contractors to operate in combat areas and that construction projects in corps rear areas should be accomplished by troops. Had the combat phase continued with heavy fighting as originally envisioned, it is possible that some contractors would not have remained on the job, and the reduced engineer structure would have been too small to support sustained combat operations. On the other hand, contractors did an enormous amount of work and most of them did it very well, with some working under dangerous conditions. The one certain lesson is that if contractors are to be relied upon to support contingency operations, they should be prepared and equipped beforehand for the conditions to be found in a theater of

operations, including provision of life support items as appropriate.

Theater Environmental Policy

Environmental considerations became a major factor in the redeployment phase. It was necessary to dispose of hazardous wastes in ways which safeguarded the fragile desert environment. Hazardous wastes included corrosive wastes (battery acid, lime sludge, acid solvents and cleansers, and caustic liquids), reactive wastes (nitric, sulfuric, and chromic acids, peroxides, perchlorates), ignitable wastes (paint thinners, solvents, POL), and toxic wastes (PCB, waste oil, dry cell and lithium batteries, hydraulic fluid, protective mask filters, antifreeze, chemical detection kits, and medical supplies). Responsibility for developing a theater environmental policy and planning the collection and disposal of hazardous wastes fell to the 416th Engineer Command.[70]

In peacetime the mission of disposing of hazardous waste is the responsibility of the Defense Logistics Agency (DLA), but CENTCOM decided in October 1990 that this mission would have to be done in the theater by engineer troops.[71] This meant that the engineers would have to create a capability to accomplish a mission for which there were no peacetime organizations, no training, and only such experience as could be gained from civilian employment. The ARCENT Engineer Section became responsible for theater environmental policy and passed the mission to the 416th Engineer Command.

The Engineering Section of the 416th Engineer Command was aware of the potential for environmental problems from the start, and the Advance Party of the 416th started working on a theater environmental policy in October 1990. In December 1990, the ARCENT Engineer Section increased its emphasis on countering potential environmental problems, and the 416th Engineer Command was appointed executive agent for environmental policy upon arrival of the main body of the headquarters. Environmental policy was a low priority item during the buildup and the war itself, but the early end of combat and the realization that the troops would be redeploying sooner than expected caused high level attention to be focused on the issue in March and April 1991. CENTCOM Theater Environmental Redeployment Procedures were issued on 27 March 1991, and ARCENT Environmental Implementing Instructions, on 2 April 1991. On 11 April 1991, the 416th Engineer Command issued guidance to all Army units on the turn-in of hazardous wastes to approved collection points.[72] The 416th also prepared a scope of work for a Theater Environmental Assessment that was accomplished by Bechtel International Services, Inc.

While the policy was being formulated and issued, the task of establishing a system for hazardous waste collection and disposal went forward. An RFP was issued in December 1990 for a contract to do the work; however, only one, unsatisfactory bid was received.
Because of the urgency in starting the work, Bechtel International Systems, Inc. was tasked

under its Gulf Peace Fund contract to open waste collection sites in Saudi Arabia. The Gulf Peace Fund was established to administer $2 billion in assistance in kind funded by the Government of Japan.[73] One site was opened in Dhahran on 5 April 1991, and nine additional collection sites were opened later throughout the area. The waste was placed in containers, labelled, recorded, and shipped to the collection sites with accountability maintained by hand receipts. All waste was shipped to the Dhahran site for processing. Provisions made in the theater for the collection and disposal of hazardous materials were adequate under the circumstances but could have been better if the necessity for this program had been recognized earlier. This is an important new aspect of military operations in an underdeveloped region.

Support of Kuwait Restoration

One hundred two members of the 416th Engineer Command were assembled at Jubayl on 28 February 1991 under the command of General Schardein as the engineer element of Task Force Freedom formed to provide support for the restoration of Kuwait. The engineer organization included a forward element of 416th Engineer Command Headquarters, a detachment of the 535th Engineer Detachment (Prime Power), and the personnel for the Damage Assessment Teams (DAST). Task Force Freedom was commanded by Major General Robert Frix, Deputy Commander and Chief of Staff of ARCENT, and included the 352nd Civil Affairs Command, under Brigadier General Howard T. Mooney, and medical and logistical units.

Nine Damage Assessment Teams (DAST) (6 Army, 1 USAF, 1 UK, and 1 Saudi) with 36 personnel moved into Kuwait City on 1 March 1991 immediately after the city was liberated. Based on extensive coordination within the engineer community and with the 352nd Civil Affairs Command, these teams were organized on a functional basis to assess the damage to power, food supply, water supply, food storage, medical, sanitary, transportation, telecommunications, and government facilities in Kuwait to provide a basis for the recovery and reconstruction work of the civil affairs units. The DASTs worked for the Combined Civil Affairs Task Force of the 352nd CA Command and provided 94 surveys to the CA Command in eight days. One DAST report identified 55 generators at key locations for priority delivery of fuel. Other DAST reports identified specific damage to the ports, airfield, sewage treatment plants, and health facilities. Particular attention was paid to food distribution facilities. Subsequently, the DASTs assisted in the transfer of responsibility for Kuwait emergency recovery from the CA Command to the Kuwait Emergency Restoration Office (KERO) of the US Army Corps of Engineers by transferring reports and data bases to KERO and conducting a workshop on the previous findings.[74]

411th Engineer Brigade Operations

The 411th Engineer Brigade was responsible for accomplishing troop construction projects for the EAC. It planned, scheduled, and supervised over 200 projects in 90 days. It also obtained and distributed the necessary construction materials to do the work.

The 411th Engineer Brigade decided to form two task forces using each of its two combat heavy battalions as a nucleus for attaching all of the eight separate companies to a battalion. Although this was in accordance with engineer doctrine, the necessity to supervise three organic combat heavy companies plus 4 additional companies stretched the command and control capability of the battalion headquarters. The problem was alleviated to an extent by adding 5 additional officers to each battalion staff. Each battalion task force had about 1,200 personnel to employ in a variety of construction projects. The alternative of having the separate companies report directly to the Brigade headquarters was evaluated and discarded, and the use of the battalion headquarters to run these heavy task forces proved to be an effective solution that allowed the battalions to focus on running the projects and the brigade to focus on supporting the battalions.[75]

In order to supervise the two task forces and deal with the consumers of engineer work, the 416th Engineer Command, and higher headquarters, the 411th Brigade set up two command posts. The main headquarters was in Dhahran in close proximity with a major consumer of engineer effort, the 22nd Support Command. This also placed the main headquarters in a position to be involved intimately in the procurement by contract of engineer construction materials. A forward element of the Brigade headquarters headed by the Brigade S-3, Lieutenant Colonel Michael Corrigan, was co-located with the 22nd Support Command Forward Element at KKMC. The forward element of the 411th Brigade contained about two-thirds of the headquarters' operations section, and half the engineering section plus representatives of the other staff sections.

The close relationship between the 411th Engineer Brigade and the 22nd Support Command initially created a disconnect in planning and implementation of engineer work because the priorities and projects preferred by the 22nd Support Command often were at variance with those of the 416th Engineer Command. In effect, General Storat was getting his guidance from General Pagonis, and General Mulcahy from General Yeosock. After some early difficulties, the ARCENT Engineer Section worked out a common set of project priorities which mitigated what was starting to be a problem between the 411th Engineer Brigade and its higher headquarters, the 416th Engineer Command. Among other things, this caused the support of enemy prisoner of war camp construction to receive a higher priority than it otherwise would have enjoyed.[76]

The composition of the two task forces is shown in figures 8 and 9. The 43rd Engineer

Battalion Task Force was headquartered at King Khalid Military City, and the 864th at Log Base Bastogne.

Figure 8.
43rd Engineer Battalion Task Force

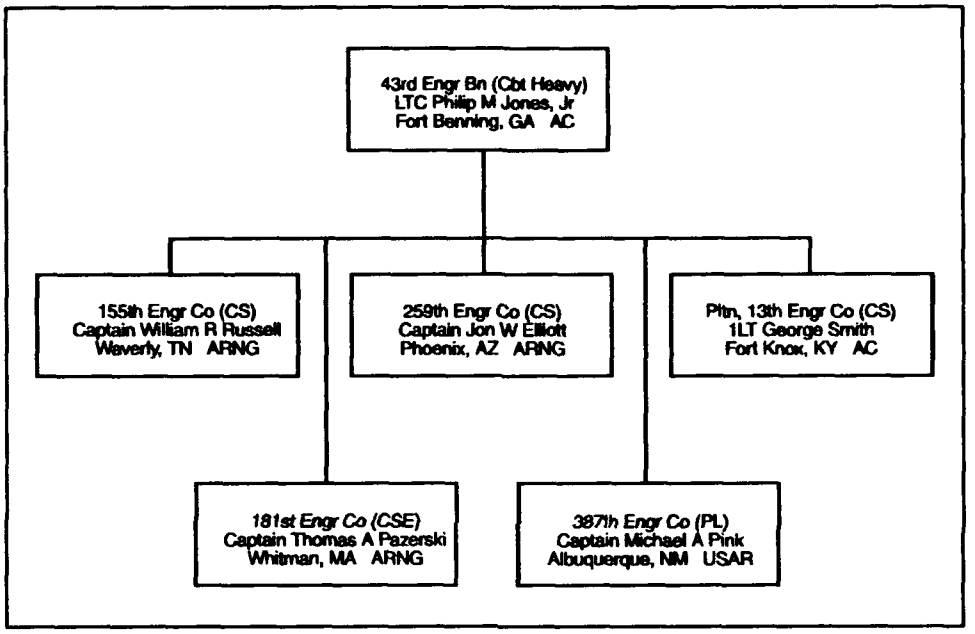
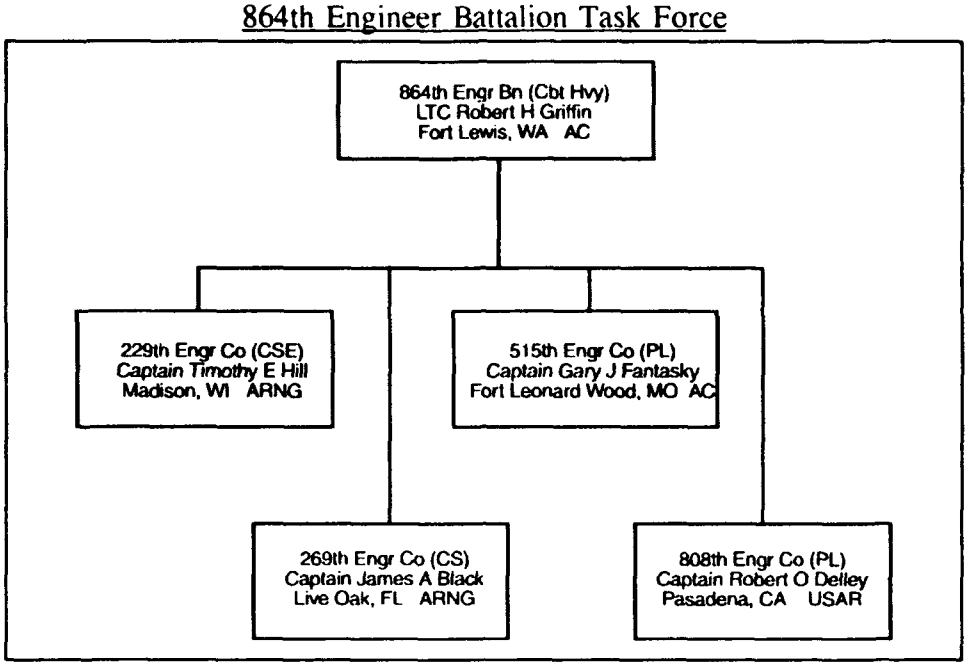


Figure 9.



Inland Petroleum Distribution System

The Inland Petroleum Distribution System (IPDS) was built to reduce dependence on delivery of fuels by tanker truck over the MSRs by supplying 12% of theater requirements for diesel and kerosene fuels (JP1-A). It involved laying 290 miles of tactical pipeline from coastal locations inland to Log Bases Bastogne and Alpha. This was the first use of the tactical pipeline system to distribute fuels; earlier exercises had tested the system with water. It was also the first time that pipeline engineers, combat heavy engineers, quartermaster water supply personnel, and transportation personnel all worked together on a pipeline mission. Many valuable lessons were learned in how to train for and erect the pipeline, and despite some problems, the mission was successful, and the pipeline system worked.

On 1 January 1991 the 411th Engineer Brigade issued a construction directive to the 864th Task Force to build the pipeline system. The 515th and 808th Pipeline Companies provided the expertise and special equipment, and they were augmented by construction specialists from the combat heavy companies of the battalion. The IPDS consisted of two separate pipeline systems, one for JP1-A and the other for diesel. The JP1-A system connected existing ARAMCO and Petmark facilities to King Fahd International Airport and the Jubayl Naval Base. Multiple lines totalling 65 miles were laid for this system. The diesel system extended westward from the Kharsaniyah Pump Station to Log Base Bastogne and Log Base

Alpha. Two lines were built along the 56 miles from Kharsaniyah to Log Base Bastogne, and a single pipeline extended 152 miles further to the end of the system at Log Base Alpha. British Royal Engineers installed their own pipe over a 65 mile length of the system, with some assistance from the 808th Pipeline Company. There were problems because the US and British supplied pipe were designed for different pressures. but the two kinds of pipe were fitted together. Twenty-eight pumping stations were constructed to operate the pipeline system, and three tactical petroleum terminals were established to service vehicles. A total of 290 miles of tactical pipeline was installed. On 1 March 1991, the pipeline was completed when it reached its western point at Log Base Alpha.

The IPDS construction project was mammoth. It took 88 barges to carry the components for the system. Although one set is supposed to include all components to install a 5 mile section, some time had to be spent in identifying the parts after they were unloaded. The engineers used their own flat bed trailers to haul the pipeline and pump stations to the construction area. This was a formidable task because hauling each 5 mile set of pipe required nineteen 40 foot trailers. The work was set up so that two parties worked simultaneously. The pipeline followed the general trace of the Trans-Arabian Pipeline (TAPLINE) and valuable technical assistance, including data on elevations along the pipeline trace, was obtained from Saudi-ARAMCO technicians. The pipe was laid on the surface instead of being buried (as called for by doctrine) in order to speed up the rate of construction. Culverts were installed at numerous traffic crossings. The 864th Task Force worked closely with the 478th Quartermaster Group responsible for POL distribution. The overall rate of construction was eight miles per day--four times the book rate for two pipeline companies.[77]

During redeployment, the 864th Task Force went back starting on 18 March 1991 and recovered all of the pipe and pumps for shipment back to the U.S. The recovery was completed by 8 May 1991.

Enemy Prisoner of War (EPW) Camps

The 411th Engineer Brigade constructed four Enemy Prisoner of War (EPW) camps to be operated by the 800th MP Brigade (EPW). As the prospect of war and hopes for victory mounted, it became apparent that provision should be made to process and intern up to 80,000 EPW. The work would be shared between the engineers and the MPs.

At a meeting in mid-January 1991, Brigadier General Joseph F. Conlon, III, Commander of the 800th MP Brigade, and Colonel Douglas Cobb, the ARCENT Provost Marshal, met with Colonel Philip W. Carroll, the ARCENT Engineer, and Colonel Lee J. Pryor of the 416th Engineer Command to establish the amount and kind of engineer support to be provided the 800th MP Brigade. The result of the meeting was a memorandum of agreement signed by General Conlon and General Mulcahy. The MOU provided that the 416th Engineer Command

would design the camps to austere standards; task three engineer companies to provide construction and technical guidance; and submit construction requests (DD 1391s) for latrines, showers, wash-stands, guard towers, lighting systems, and chain link fence. The 800th MP Brigade would provide 300 soldiers to assist in camp construction, procure all materials and equipment for the camps, including concertina wire; lease generators for the lighting systems and other electrical devices; and lease trailers for EPW processing centers.[78] The camps were to be ready for use by D-Day, with engineer support available until then.

The 411th Engineer Brigade ordered the 864th Task Force and 43rd Task Force each to construct two camps. The 864th Task Force provided two engineer platoons for seven weeks to support construction of two camps in the Eastern Area (BRONX) camp complex, and some additional work was done for the 300th Field Hospital in support of the 800th MP Brigade.[79] The 43rd Task Force provided two engineer platoons for about a month in support of construction of two EPW camps in the Western Area (BROOKLYN) camp complex. The engineers provided technical assistance and trained the MPs to do much of the construction work. The 535th Prime Power Detachment, for example, helped the MPs install two 300 kw generators at each camp and inspected the lighting systems constructed by the MPs.

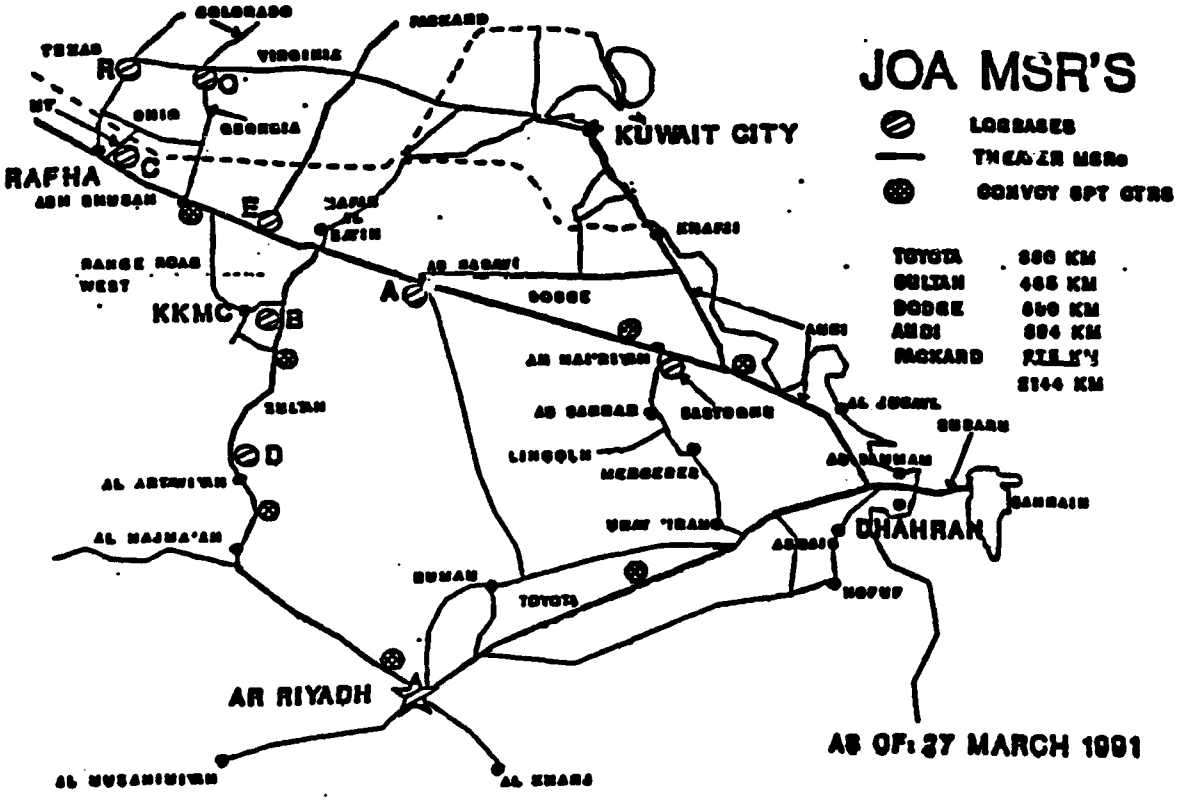
Construction of the four EPW camps was a large undertaking. Total planned capacity for the four camps was 48,000 EPW at normal occupancy with an emergency capacity of 96,000. The designs were adapted to the sites from standard Army plans, but concertina was substituted for security fencing due to the expense and delays in obtaining the chain link fence, and less lighting was provided. The engineer work involved constructing perimeter berms, providing fencing, installing lights, and constructing human waste collection systems. Developing a waste water conveyance system for the latrine and bathing facilities of the camps was a major engineering challenge. The solution adopted was to place the waste water into collection barrels; the water then flowed by gravity through pipes to pits; and finally the waste water was pumped from the pits to a settling pond downwind of each camp. This expedient design worked satisfactorily. The camps required 155 kilometers of electrical cable, 1,500 light fixtures, 15,000 roles of concertina wire, 600 rolls of barbed wire, and 36,000 long pickets. MEAPO obtained latrines, showers, and wash-stands from local contractors. The entire cost of the four camps was about $4 million, paid in full by the Saudi Government.[80]

Despite the MOU, there was a difference in the expectations of the two organizations on just how much work the engineers would do. The engineers, under pressure to work on other equally urgent projects, provided the minimum effort, relying on the MPs to perform most of the work. The MPs, for example, constructed the improvised wooden guard towers for the camps. The MPs, eager to be ready for the expected heavy load of EPWs, expected the engineers to do more work than they did.[81] Ultimately the camps were built--primarily by the MPs, but with essential and substantial support from the 411th Engineer Brigade.[82]

MSR Construction and Ma ntenance

The 411th Engineer Brigade was responsible for maintenance and repair of all of the Main Supply Routes (MSRs) in the theater and operated a comprehensive system of inspection and reporting on MSR condition to provide the 416th Engineer Command and ARCENT with up-to-date information on trafficability and problems. This was a major task, for the heavy traffic required to support the troops caused severe damage to the roads. Upon their arrival, the U.S. forces found some existing highways in good condition. Paved roads were in place from Riyadh to Dhahran, from Dhahran westward to Rafha along the trace of the Trans Arabian Pipeline (TAPLI), and from Riyadh northward by KKMC and thence t join the TAPLINE road near Hafar al Batin. The existing roads had to be maintained under heavy use by the U.S. and Coalition Forces, and new roads built across the desert to support the maneuver of the two corps in the war. Each battalion task force was assigned MSRs to maintain and each had a reaction force that patrolled the roads and responded quickly to problems. The layout of the MSRs is indicated on Map 1.

Map 1.
Operational Area Main Supply Routes (MSRs)



The major MSR was Dodge--the TAPLINE road from Dhahran westward. This was a two lane paved road with shoulders. The 864th Task Force was responsible for the Eastern 200 kilometers, and the 43rd Task Force for the Western portion. The shoulders were rebuilt, and hot or cold mix asphalt concrete was placed to repair or upgrade the pavement where necessary. During the movement of the two corps to the west in preparation for the ground campaign, MSR Dodge was designated a one-way four lane route, using both of the paved lanes and the two shoulders for convoys moving westward into their attack positions.

New roads were constructed to by-pass traffic congestion at KKMC, from KKMC to MSR Dodge, and at numerous other places to reach log bases and other military facilities. Several old engineering lessons about road construction and maintenance were relearned in the operation. The motorized road grader proved to be the most important piece of equipment for this mission, and additional graders were procured to augment those in the troop units. Initially, several graders were used in echelon to cut a ditch on each side of a proposed road and move the dirt laterally toward the center to create a mounded roadway which could withstand traffic after being compacted. However, this method of construction proved faulty when it rained, because the road shoulders became pools of water and mud as the local material (marl) reacted to the water. After a few bad experiences, the method was changed to avoid breaking the crust of the hard surface and simply "float" the road on top by mounding earth with the graders. This method worked well. Cold patch asphalt concrete prepared in an asphalt plant and then placed in a pothole and compacted by a roller proved to be the best method of repairing pot holes in the MSR.[83]

To support MSR operations and other construction projects, the 411th Engineer Brigade obtained construction materials from several sources. Quarries at KKMC, Hafar al Batin, Chris, and Majma'ah provided crushed aggregates. Ready mix concrete came from an old plant at KKMC and a small plant at Hafar al Batin. A major problem was a lack of ready mix trucks--there were only two available. Asphalt concrete was obtained from a small plant at Hafar al Batin, and larger plants at KKMC and Majma'ah. The Majma'ah plant was a long distance from the work sites, and the cooling of the hot-mix during transit caused quality control problems. The KKMC plant was an old facility put back into operation by the 155th Engineer Company courtesy of the civilian skills of some of its members. An asphalt plant just North of KKMC, operated by a contractor for MEAPO, was dedicated to paving the apron at the KKMC airfield.[84]

The combat heavy battalions were not well equipped for the road maintenance mission, even when augmented by the construction support companies. There were insufficient water distributor trucks, asphalt distributor trucks, and vibratory rollers for soil compaction. The two asphalt pavers in the 43rd Task Force were 35 years old and were out of action half the time. Cutting edges for the blades of the road graders were in short supply because of the hard soil of the desert.[85] The MSR mission necessitated augmenting the units with some of the heavy construction equipment that had been removed from the engineer troop units a few years earlier.

Airfield and Heliport Construction and Maintenance

Engineer units built hardstands for refueling, rearming, and maintenance of USAF A-10 and F-16 aircraft. Projects varied in scope from an 8,000 foot runway for C-130s to helipads for local use. Sixteen heliports were constructed to support Army aviation operations. Much of the effort at the heliports was the placement of a dust palliative to minimize the effects of the down draft caused by the helicopter blades. The best dust palliative proved to be thin asphalt mixtures, or cutbacks, which could be sprayed by asphalt distributor trucks. Diesel was sometimes used as a dust palliative if asphalt was not available but proved to be ineffective in keeping the dust down and also gummed up the pipes if sprayed by a distributor truck.[86]

Expeditionary Shelter Systems

Providing structures for troop housing and unit operations occupied much engineer effort. Five new kinds of expeditionary shelter systems were used for this purpose in the theater. Fest Tents, Clamshell Shelters, and Sprung structures consist of structural frameworks covered by fabric. K-Spans and Foam Domes integrate the covering and the structure. All of these except the K-Span structures can be erected by the using troops with a minimum of engineer supervision. These systems worked well, and while there were insufficient of these shelters to meet the total demand, even their limited availability eased the engineer workload greatly.[87]

Fest Tents (short for Festival Tents) were purchased from Germany, where they are used on holidays for temporary beer halls. Experience during REFORGER exercises in which troops moved from the United States to Germany for field exercises demonstrated the utility of Fest Tents as temporary troop facilities. They proved also to be useful in the desert for numerous activities, particularly when erected with a concrete floor.

Clamshells are a tension prefabricated structure with a shape for which the name is descriptive. One of these could be erected by a team of 4-6 men in fewer than 24 hours by the using troops, although engineers were sometimes called upon to provide tie-down systems to anchor the clamshells. This was the most popular expeditionary shelter system because of its ease of erection.

Sprung Structures are tension fabric structures of various sizes made in Canada. A fabric skin covers a metal frame, which requires a scaffolding and a crane for erection. Foundations or floors may be used and require engineer support. One hundred forty three of these structures were used in the theater.

K-Span buildings are made of thin sheets of galvanized steel which are cut to size and shaped on the building site by a automatic forming machine to make arches of a desired

dimension. A basic building 60" wide, 160 feet long, and 22 feet high takes about 10 days to construct using trained engineer troops. They provided semi-permanent, dust free facilities for personnel processing, postal operations, storage, and aircraft and vehicle maintenance. Units of the 411th Engineer Brigade constructed 47 of these buildings during the operation.

Foam Domes are a particular type of structure which consists of an inner frame upon which a thick layer of plastic foam is sprayed. When the foam hardens, it provides some structural strength as well as effective insulation. These structures had tendency to sag in the middle of the roof after a short period of time.[88] Foam domes were used to provide climate controlled facilities for medical activities, cold storage, and the theater mortuary.

Small Construction Projects

In addition to the major construction projects discussed above, numerous smaller projects were completed. A partial listing of the projects accomplished by the 43rd Task Force is presented in Figure 10. In addition to those projects shown, engineer troops built permanent and mobile tactical operations centers for ARCENT Headquarters, a graves registration site for processing and storing the remains of U.S. and Coalition soldiers killed in battle, and a complete asphalt plant with quarry and rock crusher near KKMC to provide asphalt concrete for paving operations. The engineer construction units were never out of work.

Figure 10.

Selected Small Construction Projects of the 43rd Task Force

Start Date	Days	Project Description	Unit
11 Jan 91	36	Pave 2 A-10 ramps with asphalt concrete (430,000 sq ft).	Asphalt Pltn, 13th CS Co
15 Jan 91	16	Protective construction for ARCENT briefing room.	2nd Pltn Co B
17 Jan 91	29	Earthmoving airfield parking apron (2 million sq ft).	Equip Pltn, HQ
17 Jan 91	7	Road network repairs at Saudi forward logistics base.	Earthmoving Pltn, Co A
21 Jan 91	4	Construct back blast berms for 16 Patriot missile sites.	Equip Pltn, HHCo
26 Jan 91	8	Construct 4 perimeter berms for Hawk and Patriot batteries.	Equip Pltn, HHCo
26 Jan 91	3	Construct helipad for 86th Evacuation Hospital.	Earthmoving Pltn Co C
28 Jan 91	6	Concrete floor for existing fast tent for post exchange.	1st Pltn, Co A
29 Jan 91	3	Connect electrical power to new, prefabricated building.	Co A
31 Jan 91	8	Repaired and refurbished water point at KKMC.	2nd Pltn, Co A
31 Jan 92	4	Construct breezeways and canopies for dining facility.	Co A
1 Feb 91	16	Construct graves registration facility	Co B
5 Feb 91	18	Concrete pad for KKMC post office.	2nd Pltn, Co C
6 Feb 91	13	Erect two clamshell hangers for 2nd Aviation Brigade.	1st Pltn, Co A
6 Feb 91	8	Drainage for KKMC dining facility.	Co C
14 Feb 91	1	Reinforced concrete foundation for liquid oxygen tank.	1st Pltn, Co A
17 Feb 91	35	Construct pallet staging and agricuture inspection area.	Earthmoving Pltn, Co A

Redeployment Support

Another major effort supervised by the 411th Engineer Brigade was support of the redeployment of the forces back to the U.S. Soon after the cease fire on 3 March 1991, the decision was made to redeploy the U.S. forces back to the U.S. and Europe rapidly in order to accede to the desires of the Saudis to see the Americans go and the desires of the U.S. population to see the troops come home.

Major engineer effort was required to support the various activities involved in preparing the units for redeployment. The 411th Engineer Brigade and its included units had to shift gears from projects in the desert to projects for processing the homeward bound troop units. The emphasis shifted from MSR maintenance and construction of operational facilities to wash racks and processing space. A large wash rack capable of handling 110 wheeled vehicles at a time was constructed to permit units to clean their vehicles prior to having them loaded on ships for the return journey. The pipeline which had been completed as an urgent project to support the war, was removed, prepared for shipment, and sent back to the U.S..[89] Some facilities that had just been constructed were torn down, and new temporary structures were built to provide facilities for the administrative processing of units for redeployment. Construction continued during redeployment.

Evaluation of Troop Construction Operations

Severe shortages of heavy construction equipment impacted adversely on the ability of the engineer troops to do what was required. The Army decision to rely more heavily on contractors in a theater of operations had the effect of taking away from the troop units much of the heavy construction capability which had been available in earlier wars. Such items as rock crushers, concrete and asphalt paving equipment, and heavy earth-moving equipment were eliminated as the construction battalions were converted into combat heavy battalions. Construction equipment in the engineer troop units was in many cases old and, in the words of one frustrated engineer, "35 years behind the standard in the construction industry."

Another problem was the balance between vertical and horizontal construction. The combat heavy battalions were organized with two-thirds of their capability for vertical construction and only one-third for horizontal construction, but horizontal construction was needed in the theater. Even with the extensive contractor support available for construction in the theater, the engineer units found that they needed more horizontal construction capability, and steps were taken to obtain some of it. About $4.5 million worth of heavy construction equipment was purchased or leased locally (paid for by the Government of Japan) and issued to the engineer units to augment their own equipment. The quality of equipment furnished under this agreement was not high, and there were problems in obtaining contractor maintenance.[90] Despite the problems, however, the additional equipment was highly useful.

On 25 March 1991, the 411th Engineer Brigade Headquarters turned over control of its remaining units to the 109th Engineer Group and redeployed to the US on 6 April 1991. At maximum strength the Brigade included about 2,640 military personnel. It had done the job for which it was activated and deployed.

Other Engineer Support Operations

Other engineer support operations in the theater--facilities engineering, fire fighting, well drilling, and diving operations--are covered in the sections below. The 416th Engineer Command played a role in all of these operations--except diving.

Facilities Engineering

During Operation DESERT STORM, many of the troops were housed in apartments and barracks in or near the major cities of Riyadh and Dhahran. Some were housed in the King Khalid Military City, and others made use of the austere Life Support Areas (LSA) that were built.[91] The bulk of the troops in the divisions and corps lived in the field under field conditions. The utilization of existing Saudi facilities required the creation of a system to upgrade and maintain them. This involved the integration of the commanders responsible for operating the housing facilities with the engineer troops and contractors providing the support. Doctrinally, the responsibility for housing and real property maintenance activities rests with the logistical commander--the 22nd Support Command--but in this instance the 416th Engineer Command also became heavily involved. There were problems because in many cases the troops to be housed arrived before the administrative and maintenance structure to house them was created.[92]

In the logistical structure, the Director of Engineering and Housing (DEH) is responsible for managing housing, assigning units or individuals to quarters, providing security and (in some cases) food service, and performing real property maintenance activities (RPMA)--or facilities engineering.

During August and September of 1990 as U.S. troops began to arrive in large numbers in Saudi Arabia, the arrangements for housing and facilities became confusing. Initially, staff officers from the ARCENT Engineer Section were sent to manage the major housing areas, but they were too few in number and lacked experience in facilities engineering.

The problem was alleviated somewhat in January 1991 by the arrival of two Active Component engineer colonels to take over the DEH jobs at Dhahran and KKMC respectively as part of the 22nd Support Command. Colonel Arthur Osgood, Jr., became DEH at Dharan, and Colonel Gary Morgan, DEH at KKMC. The arrival of these senior officers to lead an

expanded DEH function helped, but specific expertise in facilities engineering was still lacking, and the 416th was asked to provide additional personnel for the DEHs.

In response, three Facilities Engineering Teams (FET) of five personnel each from the 416th Engineer Command were deployed in February 1991 to help straighten out what had become a big problem in the theater. These teams were from a special TDA augmentation to the 416th Engineer Command that performs in peacetime a facilities engineering mission for the Army by managing maintenance of Army Reserve centers. The FETDA Augmentation is authorized 422 drilling reservists (247 officers and 175 enlisted personnel) backed up by 8 full time unit support personnel. These Reservists develop projects, track maintenance and repair costs, and monitor on-going projects for all Army Reserve Centers in the United States and Puerto Rico. On 17 February 1991, just after the ground war started, three Facilities Engineering Teams arrived in the theater to add expertise to the DEH offices at Dhahran, Riyadh, and KKMC.[93]

Dhahran. The largest and most difficult area for facilities engineering was Dhahran because it had the most troops to take care of and because it included Khobar Towers, a very large, previously unoccupied housing area. The DEH, Colonel Osgood, became the "Mayor of Khobar Towers." A Facilities Engineering Team, under the command of Lieutenant Colonel George Georgalis, was assigned to the DEH, and a Housing Office was established. The total strength of the DEH was 96 personnel. The 1030th Engineer Battalion, also located in Dhahran, assigned the 249th Engineer Detachment (Utilities), the 322nd Engineer Detachment (WD), the 683rd Engineer Detachment (FF), the 775th Engineer Detachment (WD), and the 1439th Engineer Detachment (FF) to support the Dhahran DEH.

King Khalid Military City. This facility had been constructed by the Kingdom of Saudi Arabia specifically to provide housing and operational facilities for military forces defending against a threat from Iraq. U.S. forces shared this facility with Saudi Forces, and there was a DEH office in place to take care of the Saudi occupants. Upon the departure of Colonel Morgan in late February to become chief of staff of 22nd Support Command, LTC Ricky Smith, head of the 416th Facilities Engineering Team, became the DEH. The DEH office in KKMC had 48 personnel. The DEH was supported by the 1439th Engineer Detachment (Fire Fighting).

Riyadh. The DEH for the Riyadh Area operated the Eskan Village housing area under the 2nd Area Support Battalion, an element of the 593rd Area Support Group. Detachment 22, a 416th Engineer Command Facilities Engineering Team staffed the DEH office augmented by members of the 2nd Area Support Battalion to a strength of about 80 personnel. The DEH was supported by the 348th Engineer Detachment (Utilities) and the 747th Engineer Detachment (Well Drilling).

Detachment 22 consisted of five engineers. Lieutenant Colonel William J. Hawes was the team leader and became the DEH. Major Michael Goreham was the teams mechanical

engineer; Captain Richard Szymarek, the civil engineer; and Sergeants First Class Nathaniel McCoy and Donald Rieke were construction inspectors.

When Detachment 22 arrived in Riyadh, it found an existing DEH of five personnel: an engineer major from the 301st Area Support (which had departed the area), a medical services officer serving as billeting officer, three enlisted clerks, and Sergeant First Class Raymond J. Lozano, of the 416th Engineer Command--the only one with previous facilities engineering experience. The situation was "out of control" with inadequate billeting records, no information on available apartments, and no key control. There were no established policies or procedures. The existing staff had tried but were too few in number and lacking the experience necessary to do the job.

Lieutenant Colonel Hawes met with Lieutenant Colonel James Bosley, the commander of the 2nd Area Support Battalion, and set up a plan to bring Eskan Village under control. The Directorate of Engineering and Housing was located in the 2nd Area Support Battalion Headquarters and was augmented by personnel from the companies of the 2nd Area Support Battalion. Lieutenant Colonel Hawes reports that in the absence of directives or guidance from higher headquarters, he and his team evaluated the situation and operated as best they could to cope with the changing situation. Billeting is not normally a responsibility of a facilities engineering team, so Colonel Hawes and his team had to use their initiative to establish a system that worked. Ultimately the billeting system included permanent housing, transient housing, visiting general officer quarters, R&R facilities, and a redeployment center. Policies and procedures, standards and rules for occupants were prepared and disseminated to the troops in Eskan Village, who on the whole were cooperative. A program of maintenance to assure the effective operation of the housing area was established.[94]

In May 1991, the amount of activity at Eskan Village had dropped tremendously because of the fast pace of redeployment. At this time, the Facilities Engineering Team was tasked to provide support for Camp Doha, which was being established just outside of Kuwait City. Major Goreham and Captain Szymarek set up the DEH office at Camp Doha efficiently and quickly. The remaining three members of Detachment 22 returned to the U.S. on 19 June 1991. Major Goreham returned to the U.S. around Thanksgiving Day, 1991, after operations at Camp Doha had ceased.

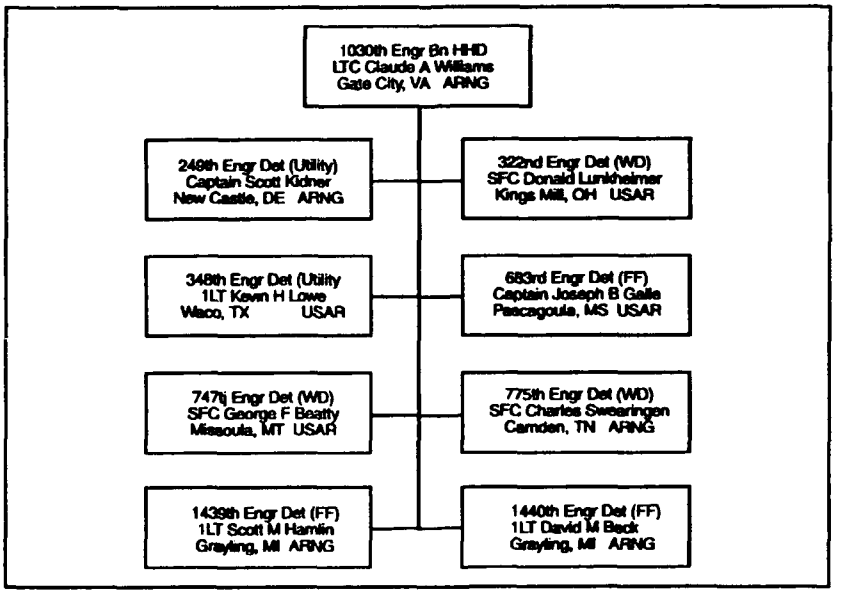
One of the lessons suggested by the facilities engineering experience in Operation DESERT STORM is that housing managers and maintenance personnel should accompany the troops to occupy the housing. The situation was fast moving as units arrived, settled into housing, and then moved out to new locations in a few days. One major problem was that units tended to hold on to their initial quarters as a sort of rear detachment location, so that newly arriving units had to compete for fewer and fewer available billets. Another problem was assuring effective maintenance of the facilities under heavy use by the troops. Water outages, power outages, plumbing problems, and air conditioning problems distracted the occupants from

their important jobs preparing for the forthcoming combat phase. If an effective DEH operation had been in existence from the start, these problems could have been avoided. Engineer personnel found themselves involved in billeting, operating hamburger stands, running post exchanges, managing laundries and supply points, and manning redeployment centers. These non-engineering missions assigned by the logistical commanders of the housing areas had to be done by someone but diverted the engineers from the facilities engineering function.

The 1030th Engineer Battalion

The 1030th Engineer Battalion, a National Guard unit from Gate City, Virginia, under the command of Lieutenant Colonel Claude A. Williams, provided command and control for numerous engineer detachments from 14 December 1990 to 15 April 1991. The 1030th is authorized 31 personnel and consists essentially of a small battalion headquarters staff. While the composite engineer battalion formed under the 1030th headquarters varied somewhat during the course of the operation, the composition and task organization of the 1030th Engineer Battalion was generally as shown in Figure 11. The total strength of the composite battalion was around 400 personnel. The 1030th Engineer Battalion Headquarters was located in Dhahran near the Headquarters of the 22nd Support Command, which had overall responsibility for the operation of the troop support areas.

Figure 11.
Composition of the 1030th Engineer Battalion



The 1030th Engineer Battalion After Action Report says that the battalion was designated as the Facility Engineering Activity for Saudi Arabia (FEASA) responsible for all ARCENT facilities engineering and tasked by the 416th Engineer Command to operate the Khobar Towers Housing Area; perform Real Property Maintenance Activities (RPMA) at Dhahran, Riyadh, and KKMC; provide air crash rescue and fire fighting support at Dhahran and KKMC; provide area damage control for Dhahran, Riyadh, and KKMC; and provide well drilling support for the entire theater.[95]

As the DEH offices grew under the 22nd Support Command and its subordinate headquarters, the scope of the 1030th's mission narrowed. It was unable to coordinate well drilling operations for the theater, and the three well drilling detachments assigned initially were reallocated to VII Corps for the combat phase.

The 1030th did have fire fighting detachments at Dhahran and KKMC. The primary mission of the 1030th, however, was to operate the Khobar Towers Housing Area at Dhahran. This was a formidable task in itself, and because the experience of the 1030th at Khobar Towers was so illustrative of the kinds of problems encountered by facilities engineers, a detailed discussion of this project, based on the 1030th Engineer Battalion After Action Report, is provided in Appendix A.

Fire Fighting

Another responsibility of the engineers in a theater of operations is to provide crash, fire and rescue services for airports and heliports, as well as fire service for installations. During the operation, the nine fire fighting detachments shown in Figure 12 were deployed.

Fire fighting detachments with the corps engineer brigades were used primarily at airfields and heliports. Three units (89th, 475th, and 907th) were assigned to the 20th Engineer Brigade, and three units (264th, 376th, and 5694th) were assigned to the 7th Engineer Brigade. The 264th Engineer Detachment was in direct support of the 11th Aviation Group and stationed fire trucks at several airfields. The 475th Engineer Detachment provided fire trucks for several airfields in the XVIII Airborne Corps area. The 907th Engineer Detachment was attached to the 27th Engineer Battalion (Corps) (Airborne) in support of the French 6th Light Armored Division and operated during the ground campaign at a forward airfield at As Salman, well into Western Iraq. The remaining three units (683rd, 1439th, and 1440th) were assigned to the 1030th Engineer Battalion to provide installation fire fighting services at Dhahran and KKMC.[96] The fire-fighting detachments deployed for DESERT STORM did their jobs professionally, but there are some indications that there were too few fire-fighting detachments in the theater to provide adequate coverage. Greatly increased activity at heliports and airfields tended to use the almost all of the fire-fighting capability that was available, leaving insufficient capability for other facilities. In one instance, for example, a tracked ammunition supply vehicle caught fire

in a motor pool and exploded, resulting in 53 personnel hospitalized and damage to a lot of equipment. If fire-fighting equipment had been available, the losses might have been reduced.[97] The experience of DESERT STORM suggests that operating in a relatively undeveloped area requires numerous well-trained, well-equipped fire-fighting detachments to minimize loss from accidental fires or those caused by enemy action.

Figure 12.

Engineer Fire Fighting Detachments in DESERT STORM

UNIT	Component	Home Station	Commander
89th Engr Det (FF)	AC	Fort Bragg, NC	SSG Leon A Leonard
264th Engr Det (FF)	ARNG	Allendale, SC	CPT James K Smith
376th Engr Det (FF)	USAR	Granite City, IL	CPT Danny W Rapert
475th Engr Det (FF)	USAR	El Dorado, KS	CPT Jerry K Lucas
683rd Engr Det (FF)	USAR	Pascagoula, MS	CPT Joseph B Galle
907th Engr Det (FF)	USAR	Pullman, WA	CPT Steven K Janzen
1439th Engr Det (FF)	ARNG	Grayling, MI	1LT Scott M Hamlin
1440th Engr Det (FF)	ARNG	Grayling, MI	1LT David M Beck
5694th Engr Det (FF)	ARNG	Shreve, OH	CPT Joseph Knott

Water Supply Operations

Water was an important factor in the war because the area of operations was primarily an arid area. There was a requirement for potable drinking water for US troops and enemy prisoners of war, and water was needed for vehicle operation, decontamination of equipment, and to service the troop housing and work areas. The primary source of drinking water was bottled water procured in the Kingdom of Saudi Arabia (which has a large bottled water industry) or imported from the US and Europe. Bottled water, however, was not appropriate for washing vehicles and aircraft, decontamination, or use in field hospitals. Existing wells and

desalinization of sea water were the primary sources of the large quantities of bulk water needed for general use. Fortunately, Northeastern Saudi Arabia already had well developed water resources because few new wells were able to be put into place during the operation.[98]

Although primary responsibility for water supply--purification and distribution--rested with the Quartermaster Corps, it was an engineer responsibility to locate and develop subsurface water supplies. The engineers located and recorded water resources and provided a well drilling capability to the theater.[99]

The 416th Engineer Command staff conducted water resources reconnaissance at the request of 22nd Support Command and maintained the Theater Water Resources Data Base (TWRDB), which provided comprehensive information for planning water supply for EPW camps, corps and EAC log support bases, and tactical water points. The existing DOD Worldwide Water Resources Data Base was outdated and inadequate for locating camps and log bases but was helpful in identifying existing water facilities in Kuwait. KSA had information on water resources, but it was hard to obtain. The 416th relied heavily on field reconnaissance to visit identified sources, check the water, and determine ownership--a very important factor in negotiating to use water from a source. For the attack into Iraq and Kuwait, aerial photography for battle damage assessment was used also to locate suspected water sources. The water resource data was compiled into the TWRDB, and overlays showing water sources were provided to engineer planners. Proximity to water sources was a major factor in locating logistical bases and EPW camps. Water sources became very important during the ground campaign because the water supply system in Southern Iraq is not nearly as well developed as that in Northern Saudi Arabia.[100]

The well drilling program in the theater emphasized re-opening existing wells rather than drilling new ones. This was because all new wells had to be approved by the KSA, and the Saudis refused permission to drill new wells in the Northern Province where the log support bases were located because of their reluctance to allow the aquifers to be depleted. The emphasis on re-opening old wells also recognized that the equipment and training of the well drilling detachments were not entirely appropriate for drilling new wells in that area.

Six well drilling detachments and one command and control detachment were deployed to the Southwest Asia Theater. Three AC well drilling detachments and the command and control detachment arrived in theater on 24 September 1990 along with the advance element of the 30th Engineer Battalion (Topographic) (Army), and were XVIII Airborne Corps assets.[101] Three RC well drilling detachments arrived in January 1991. Figure 13 shows the engineer well drilling detachments in the theater. The 98th Engineer Detachment was the command and control unit designed to maintain the well drilling equipment of the other detachments but not itself equipped to drill wells. The rest of the detachments were 10 person units equipped and trained to drill water wells.

Figure 13.
Well Drilling Detachments in Theater

UNIT	COMPONENT	STATION	COMMANDER
98th Engr Det (WD)	AC	Fort Bragg, NC	1LT Peter Passeralli
22nd Engr Det (WD)	AC	Fort Bragg, NC	SSG Johnnie McFadden
38th Engr Det (WD)	AC	Fort Bragg, NC	SSG Amadal Cabrera
322nd Engr Det (WD)	USAR	Kings Mill, OH	SFC Donald Lunkheimer
747th Engr Det (WD)	USAR	Missoula, MT	SFC George F Beatty
775th Engr Det (WD)	ARNG	Camden TN	SFC Charles Swearingen SSG John Krezinski
865th Engr Det (WD)	AC	Fort Bragg, NC	SFC Clarence Hovdy

The three Active Component well drilling detachments and their command and control detachment operated in support of 20th Engineer Brigade from the time they arrived in the theater until their departure.[102] These detachments were attached initially to the 264th Engineer Company (Medium Girder Bridge) but were attached most of the time to the 52nd Engineer Battalion (Combat Heavy) of the 265th Engineer Group. Operations of these four detachments in support of the XVIII Airborne Corps were coordinated by Sergeant First Class David Dominie, of the 52nd Engineer Battalion.[103] The 865th Detachment attempted two wells at Life Support Area Pulaski. The first attempt failed when the ground swelled at a depth of about 600' making it impossible to go down deeper or even to retrieve the drill steel. The second well in the same area was successful and produced a working source of water. The 865th was the only well drilling detachment to drill a new well successfully in the theater, but by the time the well was completed, the US forces had moved out of the area. The 865th also reopened a well in Iraq after the cease fire. Despite some difficulties in finding old wells in the desert, the 38th Detachment reopened four old wells successfully.[104]

The three RC detachments were used initially to support the DEH mission at Dhahran. During the ground combat phase they were placed in support of VII Corps. After what appeared to the unit members to be some confusion, the 775th Detachment found itself attached to the 136th Quartermaster Group at Log Base Echo, where it reopened some old wells successfully.[105]

The experience of the 747th Engineer Detachment is perhaps illustrative of the collective experience of the three RC detachments. On 6 December 1990, the 747th Engineer Detachment

(Well Drilling), USAR, Missoula, Montana, was activated under the command of SFC George W. Beatty. On 11 January 1991, the 10 members of the 747th arrived in Riyadh, Saudi Arabia with their equipment aboard a C5A Galaxy aircraft. Upon arrival, however, the unit found itself without orders or a higher headquarters. After waiting around Riyadh in transient billets for five days without instructions, the detachment commander noticed an engineer guidon at a building and inquired within. The engineer unit was the 416th Engineer Command, and the next day the 747th was assigned to the 416th Engineer Command, further attached to the 1030th Engineer Battalion, and provided a permanent billet and a mission. From 17 January 1991 to 18 February 1991, the 747th Detachment worked with the 2nd Area Support Battalion, which was operating Al Eskan Village, a troop housing facility in Riyadh. The detachment helped construct a security fence and brought an abandoned water well back into service to provide a backup source if the city water supply was disrupted. On 19 February, the detachment was attached to the 926th Engineer Group in support of VII Corps and moved forward with the ground attack on 24 February 1991. The 747th, with its well drilling equipment and four trucks, moved at night with the other support elements and found itself 130 miles deep into Iraq at the cease fire on 3 March 1991. On 6 March 1991, the detachment moved with some explosive ordnance disposal personnel into Kuwait where it put back into service two water wells which had been damaged by the retreating Iraqis. On 9 March 1991, the detachment left Kuwait and returned to the 926th Engineer Group location in Iraq, and subsequently to Saudi Arabia for redeployment to the U.S. During its time in Saudi Arabia, the detachment drilled no new wells, but it did put three back into service.[106]

The lack of success of the six well drilling detachments was due primarily to their limited capabilities and secondarily to the way they were managed in the theater. The well drilling detachments were neither equipped nor trained to achieve success in the desert. Although the equipment was new, it was inappropriate for the mission, and neither the AC nor the RC detachments were trained for or had practiced drilling deep wells. The primary producing aquifer in the region had an average depth of 300 feet in the log base areas, but averaged from 1,200 to 1,500 feet in the life support areas.[107] The well drilling detachments were capable of drilling wells down only to 600 feet, so they lacked the ability to drill successful wells in some areas, which caused frustration in the detachments.[108] Two 1,500 foot well completion kits had been shipped to the theater from Diego Garcia, but the troops had not trained to establish deep wells and had difficulty doing so. In addition, the well completion pump kits were too small to support the demands of a corps or EAC water point.[109] Finally, the construction times for these deep wells are 60 days or more, so that they would not have been ready in time to support the theater even if successful.

It appears that the engineer well drilling detachments were not incorporated adequately into the overall plans for water supply. During DESERT SHIELD, KSA permissions, hydrologic information, and taskings to drill or reopen wells were provided the AC teams by ARCENT. However, when DESERT STORM started, the 3 detachments under 20th Engineer Brigade moved forward, and ARCENT lost control of this part of the effort. The 1030th

Engineer Battalion was able to direct the work of the three RC detachments for a short time only, because they were shifted from their DEH mission to the 7th Engineer Brigade during the ground combat phase. Contractors were able to drill 11 wells successfully (out of 13 tasked) in the theater, but they were slow and unable to support tactical operations in the desert.

Water never became a logistical constraint in Operation DESERT STORM. However, the experience of the 747th and the other well drilling detachments suggests that greater thought should have been given to the proper preparation, employment, and command and control of the well drilling effort prior to their deployment. Centralized control and direction of the well drilling detachments-possibly by the 416th Engineer Command--would have been better than the decentralized system that happened. Although water was an important problem in the arid environment of the theater, the engineer well drilling detachments added little to the solution.

Diving Operations

Although not under the 416th Engineer Command, engineer units also provided diving support in the Southwest Asia Theater. The U.S. Army Diving Detachment (Provisional) deployed under the command of Captain Richard O'Donnell to Dammam, Saudi Arabia, on 30 January 1991, with a strength of four officers and 52 enlisted personnel.[110] The provisional diving detachment included three units--all active Army: 86th Engineer Detachment (Diving); 511th Engineer Detachment (Diving); and the 74th Engineer Detachment (Diving)--all stationed at Fort Eustis, Virginia, as part of the 10th Transportation Battalion (Terminal). The diving detachments were equipped with both surface supplied air (hard hat) and self-contained (SCUBA) diving equipment to assist in port construction, harbor clearance, and ship repair and salvage.

While in the theater, the Army Diving Detachment operated as part of the 7th Transportation Group. The 74th and 86th Detachments remained at Dammam Port. The 511th Detachment operated at the port of Jubayl, using an Army landing craft utility outfitted as a diving support vessel to assist in ship maintenance and terminal operations. Missions accomplished at Dammam and Jubayl included changing ship screws (propellers) and clearing them of rope and cables, and salvaging vehicles (tanks, trucks, trailers, forklifts) lost in the water. The teams also practiced underwater demolitions on a sunken ship provided by the Saudi Arabian Government for that purpose. In March 1991, teams from the Army Diving Detachment moved to Shauiba Harbor in Kuwait to assist in evaluating the feasibility of using that harbor for moving supplies in and equipment out. Except for a few small sunken boats and watercraft, the harbor was found to be in very good condition, and it was determined that the obstructions could be removed once explosive ordnance disposal units had cleared the harbor of mines. The 86th and 511th Detachments moved to Kuwait with the diving support vessel and a 100 ton floating crane from the 7th Transportation Group. The divers removed a harbor pilot boat, a steel hulled work boat, a 90 foot sludge barge, and a 140 foot STYX missile boat from the harbor. Upon completion of the Kuwait mission, the detachments returned to Dammam to

continue their support of port operations there until redeployment to the United States in three increments during May, June, and August 1991.

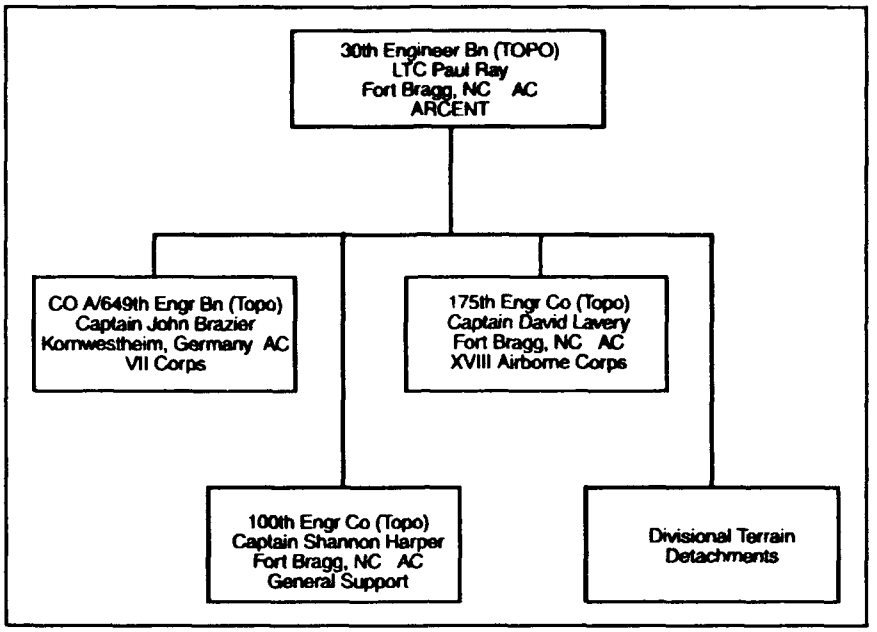
30th Engineer Battalion (Topographic)

The 30th Engineer Battalion (Topographic), commanded by Lieutenant Colonel Paul Ray, coordinated the topographic effort in the theater.[111] The 30th is an Active Army unit stationed at Fort Bragg, North Carolina, in general support of Third U.S. Army, and is one of four topographic battalions maintained in the force structure. The other topographic battalions are the 649th stationed in Europe to support US Army Europe, the 29th stationed in Hawaii to support US Army Pacific, and the 1203rd, a National Guard unit from Dothan, Alabama, for general support. Before the Iraqi invasion, the 30th Engineer Battalion was configured as part of the XVIII Airborne Corps and included, in addition to its topographic companies and detachments, the 264th Engineer Company (Medium Girder Bridge) and the 362nd Engineer Company (Combat Support Equipment), to which were attached four well drilling detachments and a fire-fighting detachment. The non-topographic units deployed to Saudi Arabia as part of the 30th Engineer Battalion, but upon arrival in the theater, were attached for operations to the 36th Engineer Group of the 20th Engineer Brigade.

In accordance with Army doctrine, a topographic battalion was provided for the theater, a topographic company for each corps, and a terrain detachment for each division. The 30th Engineer Battalion included the 100th Engineer Company, augmented by three terrain detachments and a printing detachment and the 175th Engineer Company, augmented by four terrain detachments.[112] Each topographic company had a strength of about 125 personnel including the augmentations. Company A of the 649th Engineer Battalion supported VII Corps and provided two platoons to support the 1st and 3rd Armored Divisions respectively. The other five US divisions in the theater each had their own assigned terrain detachments.[113] The organization of Army engineer topographic units in the theater is shown in Figure 14. In addition, the Marine Corps had two topographic platoons in the theater, and the British had the 14th Topographic Squadron.

Figure 14.

Organization of Engineer Topographic Units in the Theater



Provision of topographic support was a high priority item from the start of the operation. When Colonel Flowers arrived in Saudi Arabia on 4 August 1990, one of the two officers he took with him was the XVIII Airborne Corps topographic staff officer. The first two EAC engineer units deployed to the theater were topographic units. A map distribution element composed of a squad from the 100th Engineer Company and some personnel from the 175th Engineer Company arrived at Bahrain on 22 August 1990 to augment the Theater Map Depot there, and a team from the Survey Platoon of the 30th Engineer Battalion arrived on 27 August 1990. The advanced element of the 30th Engineer Battalion Headquarters arrived on 24 September 1990, and the main body of the 30th closed in on 5 December 1990. Upon arrival, the 30th Engineer Battalion was placed in direct support of the ARCENT G-2.[114] When the 416th Engineer Command Headquarters became operational in the theater on 12 December 1990, the 30th Engineer Battalion was made a subordinate element of the 416th. This worked well. The 416th Engineer Command Intelligence Section assumed staff oversight responsibility and assisted in setting priorities for production and distribution of maps and special topographic products.[115]

Continuous topographic support for the deployed units was provided by changing the missions of the topographic companies during the deployment. The 175th Engineer Company arrived on 24 September 1990, to assume its peacetime mission as the direct support topographic

company for XVIII Airborne Corps, but its equipment was still on ships. During the several weeks it took for the equipment of the 175th to arrive, the 100th Engineer Company supported both XVIII Airborne Corps and ARCENT from its home station at Fort Bragg, NC. When the 175th became fully operational in the theater after its equipment arrived, the 175th took over the mission of providing direct support for the XVIII Airborne Corps as well as providing general support for ARCENT while the 100th Engineer Company was en route to the theater. The 100th Engineer Company arrived on 5 December 1990 to resume its normal mission of providing general support to ARCENT. Company A, 649th Engineer Battalion arrived from Germany on 7 December 1990 to support VII Corps under the 7th Engineer Brigade.

Special Topographic Products

One of the important missions of the 416th Engineer Command in the Southwest Asia Theater was provision of special topographic products, which include special maps and overlays, terrain analyses, and other products designed to assist commanders to appreciate the terrain and environment of the theater.[116] The responsibility to provide standard maps and aeronautical charts of the theater rested with the Defense Mapping Agency (DMA), but the Army was responsible to provide overprinted maps, overlays, and terrain analyses specifically for the troops in the theater. The Army effort was based on the work of the Topographic Engineering Center, Fort Belvoir, Virginia, and Army topographic units in CONUS and the theater.[117] Basically, DMA provided the geodetic grid, terrain data, and the base maps to the Army, which distributed them to the troops and used them to tailor specific products for the commanders. Unfortunately, the DMA data bases for the Kuwait Theater of Operations were outdated, and the terrain overlays inaccurate.[118]

The Topographic Engineering Center (TEC) was a key element in translating DMA products into products tailored specifically for Operation DESERT STORM. Much topographic information today is compiled and maintained in digital format, so that complete maps can be transmitted in the form of a computer diskette for modification and/or printing. In effect, DMA maintains a digital map of the Earth. TEC devised a computer program to translate the DMA digital data into forms directly useful for the topographic units in the field. In addition, TEC produced climatological handbooks, terrain analyses, water resources data, and many other products for the war effort. One interesting product in particular was the use of computer generated images to provide a commander with a three dimensional view from varying perspectives of the terrain over which he would have to maneuver. TEC support was critical to the effective operations of the topographic units in the theater.[119]

Terrain analyses were important to the successful prosecution of the ground combat phase of the war. The intelligence preparation of the battlefield prior to the initiation of a campaign starts with an analysis of the terrain over which the battles will be fought. This is important, for merely reading maps--even good ones--can be misleading. On a 1:1,000,000 strategic

planning map the Wadi Al Batin appeared to be a geologic rift--a formidable obstacle--but on the ground it turned out to be passable for both tracked and wheeled vehicles. The 1st Armored Division relied on the commander of its terrain detachment, Warrant Officer Leon Mack, for key input in planning the advance of the division northward during the attack. Warrant Officer Mack and his team examined the terrain and concluded that the division could "go slow" through the supposedly impassable terrain facing them, and the division did get through without trouble. Ironically, however, Warrant Office Mack's own vehicle--a CUCV--got stuck en route. The 30th Engineer Battalion was able to depict the Iraqi barrier systems, including ditches, mine fields, fire trenches, and fortifications on special maps prepared for the attacking units. Topographic support of the theater can be adjudged a great success, and the combination of new technology with traditional military terrain appreciation proved to be very helpful in the desert environment.

Topographic units in the theater turned out numerous special maps and analyses for specific missions, ranging from five copies of a special map for a Special Forces team, to thousands of copies of base maps with additional information overprinted. Altogether, the 30th Engineer Battalion and its subordinate units produced over 200 different topographical map products between 15 December 1990 and 24 February 1991.[120] These included 51 division templates, 9 water resources studies, 12 construction aggregate studies, 4 main supply route analyses, 200 surveys, and reproducing 180,000 map sheets.[121] A total of 800,000 maps were printed using the presses in the 175th Engineer Company and the 100th Engineer Company. Much of this work was done using two new map making systems which were procured from commercial sources and issued to the 30th Engineer Battalion a few months prior to the deployment.[122]

Surveying

In order to hit enemy targets it is essential to know one's own location, and one of the most important topographic functions is to provide precise locations for artillery and air defense units, radar and communications facilities, and other military facilities. In Saudi Arabia, the distances were so great and the existing control points so few, that new methods of surveying based on the Global Positioning System (GPS) were used for the first time to provide surveying support to the Army and other Armed Forces. The engineers established a set of third-order control points that were used by other units to calibrate or initialize their own instruments. Artillery units, for example, used the location of a surveying control point to initialize their own Position and Azimuth Determining System (PADS) units so that the artillery surveyors could provide fourth-order control to the guns. Establishing third-order survey control in the theater was the responsibility of the Survey Platoon of the 30th Engineer Battalion, commanded by First Lieutenant Victoria L. Vogel.[123]

When the Survey Platoon arrived in Saudi Arabia it found only one precise (or absolute)

point available from which to measure locations for other control points. The single precise control point had been placed by the Defense Mapping Agency at an air base at Dhahran several years previously using Doppler based methods. Surveying teams established a chain of control points in eastern Saudi Arabia northward past Jubayl to Nariyah and then westward to Hafar al Batin and Rafha. Another chain was established between Dammam and Riyadh. Distances were so great that conventional surveying methods using line of sight equipment would be too slow, so new methods relying on the GPS satellites were use to measure the locations of the new control points relative to the existing precise control points. The GPS method worked well, but it sometimes took two hours to get the required readings from six satellites, and it was necessary sometimes to move around to get any readings at all. While this was taking place, the platoon established three more Doppler precise control points in Northeast Saudi Arabia and GPS precise control points at Hafar al Batin and Rafha. The Survey Platoon also found some confusion among three local coordinate systems (datums) used in the region. A computer transformation program was created to convert local coordinate systems to the World Geodetic System of 1984 (WGS84), the standard for the Department of Defense. After the arrival of VII Corps, the Survey Platoon assisted the surveyors of Company A, 649th Engineer Battalion to learn how to use the GPS.

During January 1991, preparations were made for providing survey control during the attack into Iraq and Kuwait. The chain of control points had been extended westward past Hafar al Batin to Rafha to serve as a line of departure for both VII and XVIII Corps, and control points had been set on the Saudi-Iraq border to serve as jumping off points for the attack. When the Air War Started on 16 January 1991, the Survey Platoon separated into two teams. One team under Staff Sergeant Timothy J. Funk continued West with the XVIII Airborne Corps Artillery; another team under Staff Sergeant Mark Lafler supported VII Corps and the rest of the theater from KKMC.

When XVIII Airborne Corps attacked on 24 February 1991, Sergeant Funk's survey team, escorted by an armored personnel carrier, moved out to establish control points 10-15 kilometers ahead of the artillery units. By the time the artillery arrived the control points would be waiting for them to set their PADS. Because the attack was moving faster than anticipated, the survey team had to move out ahead of the artillery without an escort, and with friendly artillery shells passing over their heads. Sending location data through channels to artillery headquarters was taking too long, so the surveyors handed the data personally to the artillery surveyors or tacked the data to the steel pickets marking the control points. Control points in the desert were marked with tripods with reflectors and blinking lights so that passing vehicles could stop and learn their location. This proved to be a valuable service. The traverse was extended northward into Iraq and then westward toward Basra. When the ground war ended on 1 March 1991, they ended the traverse with a control point about 30 kilometers west of Basra. Working with Marine Corps, British, French, and Saudi Arabian surveyors, the Survey Platoon had used a new, high-technology system to provide the precise location data that permitted the effective use of new, high technology weapons.

Map Supply

Another important topographic mission was providing maps for the field commanders. Most of the maps which were stocked at the Theater Map Depot in Bahrain at the outbreak of the war were of Iran, since that was the anticipated foe in the theater. Coverage of Saudi Arabia, Kuwait, and Iraq was incomplete and in some cases outdated. DMA spent the first few months after the Iraqi invasion providing new or updated coverage of the actual area of operations, and this was done in time to support air and ground campaigns.

There is a question about the scale used in the theater for topographic maps. The decision was made by CENTCOM early in the planning to use 1:50,000 maps instead of trying to provide the smaller scale 1:100,000 maps.[124] This is an important issue, for the area of operations was large and in comparable terms stretched from Washington, DC, West to Columbus, Ohio, and North to Detroit, Michigan. It took about 2,500 of the 1:50,000 map sheets to provide coverage of the area of operations, and DMA undertook to provide 15,000 copies of each map sheet.[125] Using 1:100,000 scale maps would have reduced by a factor of four the number of sheets required. The small area of coverage of the 1:50,000 map sheets meant that during the attack phase the units were moving out of their map sheets at a rapid rate, and some of the large stocks of map sheets that could not be distributed below division level were destroyed or abandoned.[126]

The map scale problem originated with the separation of the Army into light and heavy forces. Light divisions--airborne, air assault, light infantry--operate with 1:50,000 scale maps because the increased detail on the maps is compatible with their tactical mobility (foot). Heavy divisions--armored and mechanized infantry--generally operate with 1:100,000 scale maps because they can move quickly over large areas on the battlefield in their trucks and armored vehicles, and the smaller scale map is used in Europe and at the National Training Center. The order of arrival of the forces into the theater probably influenced the decision on map scale. The first units on the ground in the theater were light units--the 82nd Airborne Division and corps troops of the XVIII Airborne Corps--and these units preferred the 1:50,000 map scale. Although the later arriving heavy units--the 24th Infantry Division (Mechanized) and the divisions of VII Corps--would have preferred the 1:100,000 scale maps, they had to live with the consequences of the early decision by CENTCOM to standardize on the larger scale map. The map scale experience suggests that it may be difficult to standardize on a particular set of maps for future operations involving both light and heavy forces.[127]

To provide effective support for the corps, the 30th Engineer Battalion established and operated a Consolidated Corps Map Depot at King Khalid Military City manned by personnel from the 100th and 175th companies and Co A, 649th Engineer Battalion.[128] Locally procured materials and tents, including a festival tent, were used to keep rain and sand from the maps. The Consolidated Corps Map Depot broke down 10.8 million map sheets for distribution to the divisions and other corps units in a six week period.[129]

Two USAR topographic units participated in Operation DESERT STORM. The 1085th Map Distribution Center, Annapolis, Maryland, under the command of Captain David H. Cordle, provided a six person map distribution team to augment U.S. Forces Command's map distribution section at Fort Gillem, Georgia. The 1085th is a TDA unit with 108 personnel designed to provide US Forces Command a capability to accomplish the map distribution function. A total of 33 unit members volunteered to serve 30 day tours of active duty or extended annual training at Fort Gillem in order to distribute maps to deploying units of all components. In addition, the unit distributed maps from its home station during its inactive duty training periods.[130]

The 624th Engineer Detachment (Map Depot), Granite City, IL, was called up on 10 September 1990 and arrived in the theater on 1 October 1990 under the command of Staff Sergeant Ervan V. Reeves.[131] The 12 members of this detachment were placed under the operational control of the Theater Map Depot (TMD) on Bahrain operated by Defense Mapping Agency personnel.[132] Prior to the war, the 624th was a platoon with 38 personnel, but it was broken up into three detachments, only one of which was called up. By mid-January 1991 the 624th had a reduced effective strength because of physical profiles and emergency leave. As a result, the TMD was short of personnel and reported difficulty accomplishing the mission.[133] The 624th Engineer Detachment reported that they worked 12 hours per day seven days a week for six months prior to their return to the U.S. and inactivation in April 1991.[134] The TMD distributed 50 million maps during the operation.

Role of the 416th Engineer Command

In the aftermath of DESERT STORM, the role of--and even the necessity for-the 416th Engineer Command has been questioned. A preliminary Army lessons learned observation concludes that "with only two Engineer Battalions (Combat Heavy) and one Composite Engineer Battalion at Echelons Above Corps (EAC), an Engineer Brigade was sufficient to command and control this size force....An Engineer Brigade is therefore necessary, and serve (sic) the traditional role of an ENCOM. The ENCOM, however, would be redundant in this role."[135] This initial report says that the 416th was not needed.

However, in the actual sequence of events, the 416th Engineer Command arrived before the 411th Engineer Brigade, and so another question is: given the engineer command, was it necessary to have an engineer brigade? Certainly the relationships between the two general officer commands were strained at times. The after-action report of the 411th Engineer Brigade says in several places that relations with the 416th were improving--implying that they were not very good earlier. It is possible that there was some overlap between the two headquarters with too few battalions and companies to supervise.

The officers of the 416th Engineer Command realize that these issues exist. They make

a clear distinction between what they had to do in the theater and what the 411th did. In fact, the leadership of the 416th was instrumental in having the 411th Engineer Brigade activated while the need for a brigade was being re-examined. Even if the brigade would not have the two groups and five or six battalions intended originally to serve under it, the 416th Engineer Command leaders understood that the 416th alone would have insufficient engineer officers to handle simultaneously the different functions of a theater army engineer headquarters and a numbered field army engineer headquarters.[136] In the view of the 416th Engineer Command, the capability of the brigade headquarters for construction management was needed for two battalions as much as for five battalions.

What then were the capabilities of the 416th Engineer Command headquarters that justified its existence--other than the troop construction mission? The answer is in the professional engineering skills of the members of the headquarters, and particularly those in the Engineering Section. The three basic elements of the engineer staff mission for a theater or theater army are construction planning, project design, and construction management. The engineer staffs at CENTCOM and ARCENT did the overall construction planning as to what was needed and how much (although assisted greatly by members of the 416th Engineer Command staff). The 411th Engineer Brigade and the group and battalion staffs performed the job of construction management by planning and supervising and inspecting the work of the troops (although they were also overseen somewhat by members of the 416th Engineer Command staff). The key function is in engineering design. An engineer brigade headquarters is authorized to have only a limited design capability, and engineer group and battalion headquarters only a minimal design capability.[137] The capability for engineer design to support a theater army engineer mission was built into the engineer command headquarters staffing.

The 416th Engineer Command's biggest contribution--and the one which only it could provide--was to design projects and perform the technical engineering analyses essential to translate the theater construction plans into troop and contractor construction projects. That is why the presence of the 416th Engineer Command in the theater was essential to the execution of the engineer mission at the Echelons Above Corps.

It is easy, moreover, to make the case that the 416th Engineer Command should have been deployed much earlier into the theater than it was. If this had been done, many of the difficulties encountered later with respect to construction materials, theater construction management, and facilities engineering might have been avoided. Bringing the advance party of the 416th to the theater two months prior to the arrival of the main body of the headquarters was useful, for it provided in the theater both a means of focusing engineer construction planning and a capability for design, but it was insufficient to cope with the workload. Early deployment or even early activation of the 416th would have affected these problems:

--The confusion which occurred with the procurement and distribution of construction materials might have been decreased. Instead of a haphazard buildup and local

control over these materials as each succeeding engineer headquarters obtained materials for its own use, there could have been a system for centralized procurement and distribution from the outset.

--MSR Planning and construction might have been improved. An engineer command could have worked with the 22nd Support Command's Transportation Command to make a reconnaissance and engineering evaluation before the MSRs were laid out. This might have obviated some of the problems encountered with MSR Dodge.

--Coordination on the laydown of the petroleum pipeline could have been accomplished earlier, which might have precluded the necessity for an urgent construction project in December. Since the pipeline took 144 tanker trucks off the roads, earlier completion of the pipeline would have helped ease the MSR problems.

--Environmental aspects of military operations in underdeveloped areas might have received more early attention than the engineer staff sections could give them.

--The facilities engineering function could have been managed to provide the necessary support for troop housing before problems developed.

--Engineer responsibility for theater water supply could have been coordinated better and more effective use made of well drilling detachments.

--Many of the problems encountered with designing facilities and adapting standard designs to the theater might have been avoided if the design and engineering capability of the 416th had been available early on. Both the Engineer Section of the CENTCOM J4 Directorate and the ARCENT Engineer Section were occupied completely with contracting and construction planning, and neither had the time nor the skills to perform the engineering and design tasks.

One of the lessons learned by the engineers from DESERT STORM is that the construction planning and design capability for a theater requiring extensive construction of new facilities needs to be on the ground early in the build up. Even for Saudi Arabia--for which much of the construction had already been done--this proved to be the case.

Total Army--Engineer Style

Regardless of the outcome of future deliberations on how to improve Army engineer operations in future regional wars, the fact is that the engineers did the job in the desert. The facilities were built; the roads were kept open; the combat forces were able to breach the barriers and maneuver rapidly and explosively. The engineer effort, in fact, was just getting

rolling when the war ended. The pipeline was just finished. The roads were just getting in good shape. The facilities were built and being upgraded. The construction materials and the maps were under control. Had the war continued, the EAC engineers would have been able to provide what it would have taken. There are some general complaints of too few engineer units and lack of understanding by non-engineers, but these are just that--general complaints. There are also some valuable lessons that have to be learned and acted on, but the Army engineers did the job.

Not only did the engineers do their job, but they did it in a really integrated way. Engineer commanders did not hesitate to place Active Army units under Reserve headquarters. Active engineers treated Guard and Reserve engineers with respect and as comrades. Guard and Reserve engineers had a healthy attitude about their Active Army counterparts. The controversies that arose were about engineering matters, how best to use the equipment, how to improve the process, and not about who was best--Active, Guard, or Reserve. These things were not true about some other parts of the Army. Why were the engineers different? What did they do to make the Total Army work?

The engineers know that they did something good, and they have been thinking about why. Some of the reasons suggested by them are as follows:

- Engineers are professionals. One of the bonds among engineers in general, and engineer officers in particular, is that they share a common professional discipline--engineering. Most engineer officers have engineering degrees, primarily but not exclusively in civil engineering. Because of this, they can communicate with each other in a technical sense which transcends the barriers of component. Professional status is as important as Army status. Indeed, the fact that most Reserve and National Guard engineer officers work as engineers in civilian life strengthens their ties to the military engineering community. This is exemplified by the strong programs of the Society of American Military Engineers and the American Society of Civil Engineers, which unite Active, Guard, and Reserve engineers into a common framework.

- Engineers work together in peacetime. One of the most important characteristics of engineers is that they like to do something useful in peacetime--build something. There is a lot to be built, and Active, Guard, and Reserve units perform a lot of construction together in peacetime. National Guard and Reserve engineer units worked in Central America on their annual training alongside Active units. The two USAR engineer commands planned, designed, and supervised construction projects accomplished by other units, some Active, some National Guard. The 416th Engineer Command was responsible for facilities engineering support of the Army Reserve. In these joint projects, the engineers get to know each other by first names, learn to understand the strengths and

shortcomings of each component, and get to appreciate how they can all fit together into a team. General Mulcahy and his immediate predecessors as Commanders of the 416th Engineer Command, Major Generals Mark Tenny and Max Baratz, were enthusiastic supporters of joint training with and support of the active Army.[138] If the war was won for the combat arms at the National Training Center, it was won for the engineers on the many, many construction projects worked on by the engineer units of all components in many different nations in the decade preceding the war.

- Engineers are a diverse sort. Another characteristic of engineer operations is that they habitually work with many different kinds of engineers: active military units and staffs; civilian employees of the Corps; and contractors of many kinds and nations. The Corps of Engineers is a sophisticated, global organization used to dealing with big problems. Thus, its members easily could accept into their already diverse ranks the engineers of the Guard and Reserve.

- Engineers attend the same schools regardless of component. The old days in which the Reservists attended the short courses, and the Regulars the long courses are gone. The Engineer School is the focus for the development of engineer doctrine and engineer education and insists that personnel of all components meet the same standards--which for engineering subject matters gives an edge to the Reservists.

- The Chief of Engineers fosters a Total Army approach. The current Chief of Engineers and his immediate predecessors fostered a Total Army approach for all engineer officers. Guard and Reserve engineer commanders are invited to attend and participate in the Commanders' Conferences sponsored by the Chief of Engineers. Engineer units are treated the same regardless of component. The attitude displayed in the desert, of cooperation and mutual respect and support among all engineer units, started at the top and worked its way down.

Finally, some of the credit for making the Total Army Concept work for the engineers has to be given to General Mulcahy, General Schardein, General Storat, Colonel Carroll, Colonel Berg, Colonel Pryor, Lieutenant Colonel Ray, Lieutenant Colonel Williams, Major Knieriemen, Captain Senger, SFC Beatty, and all of the other engineer officers, NCOs, and troops who did their jobs cooperatively and professionally with their Active, Guard, and Reserve comrades. Despite some difficulties, they lived up to the Engineer Motto--Essayons--by trying, trying again, and ultimately succeeding.

End Notes

1. This account is based on an interview on 29 November 1991 with Colonel Philip W. Carroll, III, the ARCENT Engineer during the war.

2. LTG Henry J. Hatch, Chief of Engineers, address at Lehigh University, 6 Dec 1991.

3. Hatch, op. cit.

4. Hatch, op. cit.

5. Interview, Lieutenant Colonel Gordon Quesenberry and Mr. Harry Painton, OCE, 12 December 1991. Colonel Quesenberry also reviewed the draft manuscript and made several helpful suggestions.

6. Interview, LTC Quesenberry and Mr. Painton, 12 December 1991.

7. 416th Engineer Command, Command History Report: Operation Desert Storm, 17 January 1991 Through 1 April 1991, 22 April 1991.

8. Ibid.

9. Briefing, Colonel Alan J. Berg, 22 November 1991.

10. Telephone call with Major Paul W. Somers, Readiness Division, Air Force Civil Engineering Directorate, 2 January 1992.

11. Colonel John Braden, CENTCOM, Desert Shield/Storm "Hot Wash", 416th Engineer Command, 7 April 1991.

12. Interview, Colonel Phillip W. Carroll, III, 29 November 1991.

13. Presentation by Colonel Robert B. Flowers, 416th Engineer Command Engineer School, 14 March 1992.

14. LTG Henry J. Hatch and Janet A. McDonnell, "Laying the Groundwork for Theater Operations," Military Review, March 1992, p 10.

15. Letter, LTC Charles S. Cox, 6 April 1992.

16. Telephone interview, Colonel Alan J. Berg, 416th Engineer Command, 14 January 1992.

17. 416th Engineer Command, Command History Report, 1 August 1990 Through 16 January 1991, 20 May 1991, p 9.

18. DA's initial opposition to calling Reserve general officers was demonstrated clearly for Civil Affairs and logistical units but was overcome as the need for senior Reserve officers became apparent.

19. Colonel Carroll, 29 November 1991.

20. Headquarters, US Army Forces Central Command Support Command Provisional, Memorandum for Commander 416th ENCOM, Subject: "Mission Directive for Deployed Elements of the 416th," 1 November 1990.

21. Telephone interview, Colonel Berg, 14 January 1992. General Pagonis well understood the need for having an engineer command and control element at the Theater Army level, and at one point when the deployment of the entire 416th Engineer Command was in doubt, proposed to form a provisional engineer brigade headquarters to be commanded by Colonel Berg.

22. Interview, Colonel Carroll, 29 November 1991.

23. Telephone interview, Colonel Berg, 14 January 1992.

24. Interview, LTC Quesenberry and Mr. Painton, OCE, 12 December 1991.

25. Interview, LTC Quesenberry and Mr. Painton, OCE, 12 December 1991.

26. 416th Engineer Brigade, Command History Report, 1 August through 16 January 1991, 20 May 1991, p 7.

27. Letter, Colonel Lee J. Pryor, 24 February 1992.

28. Telephone interview, Colonel Berg, 14 January 1992.

29. Interview, Colonel Carroll, 29 November 1991.

30. Interview, Colonel Carroll, 29 November 1991.

31. Telephone interview, Master Sergeant Richard C. Cascio, 411th Engineer Brigade Operations Section, 13 Jan 1991.

32. Colonel Carroll, 28 January 1991. The 224th Engineer Battalion (Combat) (Mechanized) and the 1457th Engineer Battalion (Corps Combat) deployed to Europe.

33. Telephone interview, LTC Hirschmann, Executive Officer, 109th Engineer Group, 17 January 1991, and 109th Engineer Group response to National Guard Bureau, "Desert Storm/Desert Shield Historical Questionnaire," 20 November 1991.

34. The current official name of this program is the Engineer Restructuring Initiative.

35. Telephone interview, LTC Quesenberry, OCE, 2 January 1992. This same recommendation for tripling divisional engineer support was made at the end of World War II but was not implemented. Although the term "Regimental Engineer" was used during DESERT STORM, the engineer brigade commander is now called the "Division Engineer."

36. Office of the Assistant Chief of Engineers, 28 January 1991.

37. Colonel Flowers, presentation at the 416th Engineer Command Engineer School, 14 March 1992.

38. Interview with Colonel Carroll, 29 November 1991.

39. General Crosbie E, Saint, "War Adds New Dimensions to Europe's Role," Army, October 1991, Figure 2, p. 93.

40. Office, Assistant Chief of Engineers, 28 January 1991.

41. USARCENT Engineer Section, Operations Desert Shield and Desert Storm Briefing, April 1991.

42. Much of the material in this section is based on the presentation by Lieutenant Colonel Merrill W. Watt at the 416th Engineer Command Engineer School, Chicago, IL., on 14 March 1992.

43. LTC Watt, 14 March 1992.

44. LTC Watt, 14 March 1992.

45. LTC Watt, 14 March 1992.

46. Letter, Colonel Lee J. Pryor, 24 February 1992.

47. 416th Engineer Command, Command History Report, 17 January 1991 Through 1 April 1991, 22 April 1991, p 9.

48. Tommy R. Hill, Assistant Chief of Real Estate Operations, Savannah District, presentation at the 416th Engineer Command Engineer School, 14 March 1992.

49. Hatch, op. cit., and Hill, op cit.

50. 308th Engineer Detachment (Real Estate), Desert Storm After Action Report, 19 May 1991, and presentation by Tommy R. Hill, 416th Engineer Command Engineer School, 14 March 1992. The 308th Engineer Detachment is now receiving training in complete real estate operations, including acquisition and lease negotiation, with the assistance of the Savannah District, USACE.

51. Letter, LTC Cox, 6 April 1992.

52. Telephone interview, Mr. Bill Brubaker, Office Chief of Engineers, 28 January 1992. The thresholds have been increased since Desert Storm, so that an installation commander may approve new construction projects up to $500,000, Military Departments may approve projects between $500,000 and $1.5 million, and Congressional approval is required for projects costing over $1.5 million.

53. Presentation by Major Salvatore M. Cremona, 416th Engineer Command Engineer School, 15 March 1992, and "Command Report: Operation Desert Shield RCCM Cell Personnel Activities (1 AUG 90 to 16 JAN 91)," 9 February 1991.

54. 416th Engineer Command, Command History Report, 17 January 1991 Through 1 April 1991, 22 April 1991, pp 6-7.

55. 535th Engineer Detachment, Interim After Action Report for Operation Desert Shield and Desert Storm, 31 March 1991.

56. After-Action Report, Task Force Bravo, Engineer Battalion Prime Power (Provisional), 17 August 1991.

57. Captain Louis Adams, Commander Company A, Engineer Battalion (Prime Power) (Provisional), 13 April 1992.

58. Captain Leah Choudhury, Headquarters, Engineer Prime Power Battalion Provisional, 13 April 1992.

59. 411th Engineer Brigade, Unit Historical Report, Operation Desert Storm, 25 March 1991.

60. Colonel James R. Martin, DCS Logistics, 416th Engineer Command, 22 November 1991.

61. Comments on draft manuscript by Colonel James R. Martin, ACS for Materiel, 416th Engineer Command, 14 February 1992.

62. 411th Engineer Brigade, Unit Historical Report, Operation Desert Shield, 25 March 1991.

63. Letter, Colonel Lee J. Pryor, 24 February 1992, indicates the longer period. Other sources confirm that there was widespread absence for at least three days.

64. 416th Engineer Command, Command History Report, 17 January 1991 Through 1 April 1991, 22 April 1991, p 35.

65. Interview, Colonel Carroll, 29 November 1991.

66. LTC Quesenberry, comments on draft manuscript, 4 March 1992.

67. 416th Engineer Command, Command History Report, 17 January through 1 April 1991, 22 April 1991, p 44.

68. Letter, LTC Charles S. Cox, Transatlantic Division, USACE, 6 April 1992.

69. Letter, LTC Cox, 6 April 1992.

70. This section is based on information provided by the 416th Engineer Command.

71. The 416th Engineer Command believes that CENTCOM wanted engineer troops to perform the mission instead of relying on DLA civilian employees.

72. Memorandum, 416th Engineer Command, Subject: "Turn-in of Hazardous Wastes to Approved Collection Points for Operation Desert Storm/Desert Calm," 11 April 1991.

73. LTG Henry J. Hatch and Janet A McDonnell, "Laying the Groundwork for Theater Operations," Military Review, March 1992, p 10.

74. 416th Engineer Command, Command History Report, 17 January-1 April 1991, 22 April 1991, p 10, and Memorandum, 416th Engineer Command, "DAST After Action Report with Supplemental Data," 13 March 1991.

75. 411th Engineer Brigade, Unit Historical Report, Executive Summary, 25 March 1991.

76. Interview, Colonel Carroll, 29 November 1991.

77. LTC Brennan, 411th Engineer Brigade, presentation at the 416th Engineer Command Engineer School, 15 March 1992.

78. Memorandum of Understanding between 416th Engineer Command and 800th Military Police Brigade, Subject: "Enemy Prisoner of War (EPW) Camp Construction," January 1991.

79. 864th Engineer Battalion, After-Action Report, 30 April 1991.

80. Presentation by Major Selton J. Sampson and Captain Patrick A. Portteus, 416th Engineer Command, Engineer School, 15 March 1992.

81. Interview, Colonel Carroll, 29 November 1991.

82. See ANDRULIS Research Corporation report, Tending the Fruits of Victory: The 800th MP Brigade (EPW) in Operation Desert Storm, for particulars of the MP viewpoint. The issue has been laid to rest. At the 416th Engineer Command Engineer School on 15 March 1992, the present Commander of the 800th MP Brigade, Colonel Evo Riguzzi, thanked the 416th Engineer Command and the other engineers for their support and gave an excellent presentation on EPW operations during DESERT STORM.

83. 416th Engineer Command,, Command History Report, 17 January through 1 April 1991, 22 April 1991, p 14.

84. Major David L. Baker, 416th Engineer Command, presentation at the Engineer School, 15 March 1992.

85. 864th Engineer Battalion, After Action Report, 30 April 1991, p 65.

86. 864th Engineer Battalion, After Action Report, 30 April 1991, p 10.

87. US CENTCOM, Office of the USCENTCOM Engineer, Macro Lessons Learned for Operation DESERT SHIELD/STORM, 16 March 1991, pp 6 & 7, and presentation by Major Ronald A. Mallare, 416th Engineer Command Engineer School, 15 March 1992.

88. Letter, Colonel Lee J. Pryor, 24 February 1992.

89. Letter, Colonel Lee J. Pryor, 24 December 1992. The engineers prepared the pipeline for shipment, and a contract was let with a US firm to make final preparations and actually transport the pipeline back to the United States.

90. 411th Engineer Brigade, Unit Historical Report, Operation Desert Storm, 25 March 1991.

91. Six Life Support Areas were planned and constructed at least partially, but only two were actually used by troops.

92. This section is based on the after action reports of the 416th Engineer Command, an informal discussion with LTCs Hawes, Smith, and Georgealis at the 416th Engineer Command Engineer School, 15 March 1992, and the "After Action Report of Detachment 22," by LTC Hawes, undated. It has been difficult to find out what really happened in this particular functional area because the reports of the participants differ.

93. Telephone interview, Mr Al Smith, 416th Engineer Command, 13 Jan 1992.

94. "After Action Report, Detachment 22," 416th Engineer Command, undated.

95. 1030th Engineer Battalion, After Action Report, Operations Desert Shield/Storm, 1 April 1991.

96. Information obtained by telephone interviews with the detachments on 28 and 29 January 1992.

97. Major Kattleman, 864th Engineer Battalion, presentation at the 416th Engineer Command Engineer School, 14 March 1992.

98. Special thanks to Captain Robert Knowles, 416th Engineer Command for his review and comments on the draft of the section dealing with water supply operations. Captain Knowles oversaw water supply activities at the 416th Engineer Command level.

99. Captain Robert Knowles, 27 April 1992, cites TRADOC Pamphlet 525-32, "US Concepts for Water Support in a Theater of Operations," 12 Sep 1983, as the basis for this statement.

100. Captain Knowles' presentation at the 416th Engineer Command Engineer School, 14 March 1992.

101. Comments on draft manuscript, Captain William S. Kibler, 30th Engineer Battalion, 2 March 1992.

102. Some reports indicate that these 4 detachments were assigned or attached to the 1030th Engineer Battalion, but it is clear that regardless of their administrative status, the 1030th had no role in their operations.

103. SFC Dominie was the commander of the 98th Engineer Detachment for the initial part of the operation, until Lieutenant Passeralli assumed command.

104. Telephone interview, MSG David Dominie, Operations Sergeant, 362nd Engineer Company, 14 January 1992.

105. Telephone interview, Specialist Steven Baile, 775th Engineer Detachment, 14 January 1992.

106. 747th Engineer Detachment, Desert Storm After Action Report, 28 May 1991.

107. Captain Knowles, Memorandum for the Record, 20 February 1992. Captain Kibler, 30th Engineer Battalion, points out that there were shallower aquifers at 150-250 feet and 400-500 feet respectively that provided non-potable water, but the mission required potable water.

108. Major Jack Barnhill, Army Center for Lessons Learned, Observation 53, 11 April 1991.

109. Captain Knowles, Memorandum for the Record, 20 February 1992.

110. This account is based on information supplied by First Sergeant James P. Leveille, Army Diving Detachment (Provisional), 12 February 1992.

111. This section has benefitted from a review of the draft manuscript by Captain William S. Kibler, 30th Engineer Battalion, 2 March 1992.

112. The line-up of augmentation detachments in the 30th Engineer Battalion was as follows: 100th Engineer Company had the 20th, 538th, and 539th terrain detachments and the 42nd printing detachment; the 175th Engineer Company had the 70th, 133rd, 534th, and 543rd terrain detachments.

113. The divisional detachments were as follows: 1st Infantry Division: 84th Engineer Detachment; 1st Cavalry Division: 1230th Engineer Detachment; 24th Infantry Division: 148th Engineer Detachment; 82nd Airborne Division: 82nd and 106th Engineer Detachments; and the 101st Airmobile Division: 148th Engineer Detachment.

114. Comments on draft manuscript, Captain Kibler, 30th Engineer Battalion, 2 March 1992.

115. Comments by 416th Engineer Command Intelligence Section, 14 February 1992.

116. This section is based on an interview on 12 December 1991 with LTC Ronald Rowlette and Mr Ray Hall, Office of the Assistant Chief of Engineers and on the 30th Engineer Battalion (Topographic) After-Action Report, November 1991.

117. During the war, the name of the Army's backup facility was the U.S. Army Engineer Topographic Laboratories. The name was changed in mid 1991 to the present Topographic Engineering Center.

118. Comments on draft manuscript, Captain Kibler, 30th Engineer Battalion, 2 March 1992.

119. US Army Engineer Topographic Laboratories, Tech-Tran, Volume 167, Number 2, Spring 1991.

120. 416th Engineer Command, Desert Shield/Storm Engineer "Hot Wash," 7 April 1991, hereafter Hot Wash, p 8.

121. 416th Engineer Command After-Action Report, 20 May 1991, slide on topographic missions.

122. 416th Engineer Command, Command History Report: Operation Desert Storm., 17 January 1991 through 1 April 1991, 22 April 1991, p 61.

123. This section is based primarily on an article by Staff Sergeant Timothy J. Funk and Staff Sergeant Mark Lafler, "Desert Storm Surveying," Point of Beginning, Volume 17, Number 1, October-November 1991, pp 10-28.

124. This decision by CENTCOM apparently was made without consulting the topographic engineers or the 416th Engineer Command. Mr Robert Hall of the Office of the Assistant Chief of Engineers says that the map scale controversy was long-standing, and that there probably was no single map scale which could satisfy all users. Telephone interview, 28 January 1991.

125. Engineer Hot Wash, p 8.

126. Comments on draft manuscript, Captain Kibler, 30th Engineer Battalion, 2 March 1992.

127. Comments on draft manuscript, Captain William S. Kibler, 30th Engineer Battalion, 2 March 1992.

128. Comments on draft manuscript, Captain Kibler, 30th Engineer Battalion, 2 March 1992.

129. 416th Engineer Command, Command History Report: Operation Desert Storm, 17 January 1991 through 1 April 1991, 22 April 1992, p 5, and comments by the 416th Engineer Command Intelligence Section, 14 February 1992.

130. Telephone interview, Mr James R. Churn, 1085th Map Distribution Center, 28 January 1992.

131. Letter, SSG Reeves, 19 Dec 1991.

132. The Theater Map Depot had been established quietly in 1989 for just such a contingency.

133. 416th Engineer Command, Command History Report: Operation Desert Storm, 17 January 1991 through 1 April 1991, 22 April 1991, p 59.

134. Letter, SSG Reeves, 19 Dec 1991.

135. Major Jack Barnhill, Center for Army Lessons Learned, Observation 1, 8 March 1991.

136. General Yeosock makes the point that his command--Third US Army--was in fact three armies in Desert Storm: a component command of CENTCOM; a Theater Army Headquarters for the theater; and a field army (numbered army) commanding two corps. See "Army Operations in the Gulf Theater," Military Review, September 1991, pp 2-15.

137. Interview, LTC Quesenberry and Mr. Painton, OCE, 12 December 1991.

138. Interview with LTC Quesenberry and Mr. Painton, OCE, 12 December 1991. General Baratz is now the Deputy Commander of the US Army Reserve Command.

Appendix A: Facilities Engineering at Khobar Village*

When the 1030th Engineer Battalion arrived in Saudi Arabia on 14 December 1990, the housing situation at Dhahran was in serious trouble. Several hundred thousand troops had already arrived, but the Directorate of Engineering and Housing (DEH) operations were being handled by just three personnel from the ARCENT Engineer Staff--a captain, a warrant officer, and a sergeant. ARCENT did not have any engineer units to task to accomplish projects, and most of the work was handled by tasking transient corps engineer assets moving through the area or by submitting a purchase request to have local contractors do the work. A critical shortage of billeting, storage, and administrative space had developed, together with an enormous backlog of project and contract requests and work to be done.

Upon arrival in Dhahran, the 1030th Engineer Battalion Headquarters immediately established and staffed a DEH for the Dhahran area as part of its overall responsibility as the Facilities Engineering Activity for ARCENT.

The billeting and space problems in the Dhahran area were solved partially by the deployment of combat troops north to field locations but primarily by the opening of Khobar Village. This village consists of approximately 200 high-rise apartment buildings. One hundred twenty-six of these buildings were "T-shaped," having three flats on each level; the remainder had two flats on each floor. The buildings ranged from four to eight stories high, resulting in approximately 3,000 flats. At the initial planning factor of 10 troops per flat, the Village would easily house 30,000 troops.

The original plan was to billet all "permanent party" personnel in Khobar Village, freeing up some of the 100 individual compounds in the Dhahran area for transient troops. This plan, however, did not work for several reasons. One, a very large number of troops, especially from VII Corps, arrived soon after the village opened. Two, personnel housed initially at port facilities had to be moved because of storage requirements. Three, existing compounds either could not or would not accept the large numbers of incoming troops. At several compounds, the tenant unit would leave behind a small contingent to secure the area, thus blocking use by incoming troops. Other terrain managers refused to accept troops not within their trace. Consequently, Khobar Village became the principal permanent and transient billeting area as soon as it opened.

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* This account is taken almost verbatim from the 1030th Engineer Battalion After Action Report, Operations Desert Shield/Storm, dated 1 April 1991. Additional remarks were provided on 28 February 1992, by Major Frank Reynolds, Virginia National Guard, Operations Officer of the 1030th Engineer Battalion during DESERT STORM. Because this is such a remarkable story, it was worthwhile to present it as an appendix, with only slight editing.

There were numerous problems in obtaining the use of and in opening Khobar Village. The first problem was obtaining permission and gaining access to the buildings. The housing complex is owned by the Saudi Royal Family, who had to personally approve its use to house US troops. Even after time-consuming negotiations and this approval had been given, local Saudi officials refused to turn over buildings in a timely manner. In addition, these officials insisted on increasing the occupancy rate from the original 10 up to 20 per flat and often refused to release additional buildings until each building was physically filled to the 20/flat specification. The Saudi representatives at Khobar Village changed or delayed most of the schedules to turn over buildings, resulting in overcrowding of existing buildings, troops sleeping in parking garages, and a huge backlog of troops being delayed entry. Of the more than 200 buildings in Khobar Village, only half were ever turned over for housing troops.

A second problem was the condition of the housing project. Khobar Village was constructed 8-10 years ago, reportedly for native Bedouins who later refused to move in. Until HHD, 1030th Engineer Battalion moved into Khobar Village on 19 December 1990, no one had ever occupied any of the buildings. Although the water and electricity had been tested when the buildings were first completed, numerous problems with the utility system arose immediately.

The initial water system consisted of a combination of schedule 40 PVC (which should have been schedule 80) and metal pipes. The metal water pipes had been destroyed by the combined action of salt water and the naturally acidic soil. Many of the larger PVC lines had turned brittle and failed, probably from a "water hammer" effect when the system was being brought on line, valves being opened and closed, and air not allowed to escape. Local contractors were in the process of digging up and replacing all water lines--a process that continued the duration of the US stay at Khobar Village.

Both the new and old system often failed, shutting off all water to the buildings. The main water reservoir system had never been put into operation. The main water supply for each building-- a storage tank on top floor of each building--often leaked when filled and had to be repaired. Many of the pumps which were required in each building to fill the building's storage tanks had to be replaced, and plans showing the water distribution network and the system's valves were not available.

These problems were presented to the local Saudi representatives who initially insisted that all repairs be done by local contractors. These contractors were not available for emergency repairs and, as soon as the first SCUD was launched at Dhahran, these contractors disappeared completely. Over a 3-month period, the 1030th Engineer Battalion HHD logged in and completed over 1,000 work requests at Khobar Village. With the arrival of the 249th Engineer Detachment (Utility), the main reservoir system was placed into service, bugs worked out of both the electrical and plumbing systems, and the utility system was finally stabilized.**

** Engineer utility detachments were included in the force structure specifically to perform the kind of DEH and RPMA work performed by the 249th Engineer Detachment at